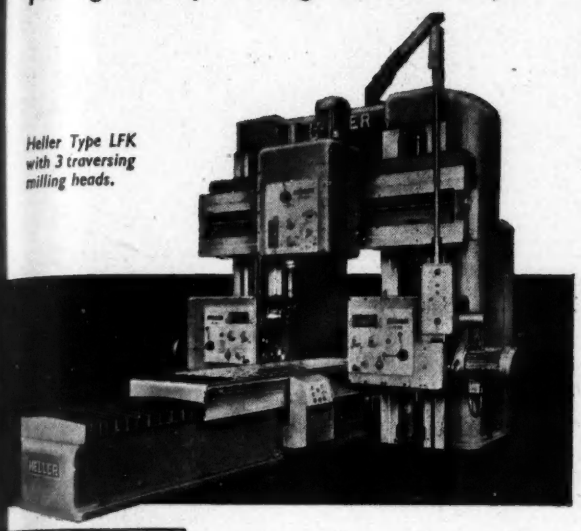
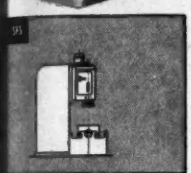
HELLER

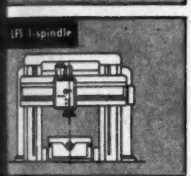
LANO-TYPE MILLING MACHINES

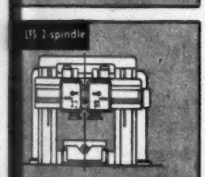
for higher output and greater economy

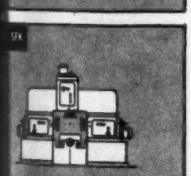


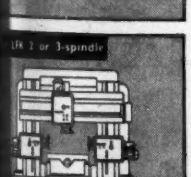
Heller Type LFK with 3 traversing milling heads.

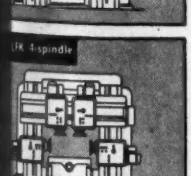












The simultaneous milling of several faces on one workpiece—often in different planes and at different angles—is the answer to the demand for increased output of many complex parts. It obviates reclamping and realigning and in many cases reduces the number of machines required for production.

Heller plano-type milling machines are designed on the unit-assembly system and can be literally 'built around the component'. The major units are the milling heads, tables, feed mechanism, uprights and frames. The selection of units depends entirely on the work required: for example, light milling heads and a large table can be used for bulky workpieces with only small faces to be milled, or alternatively heavy milling heads can be employed with a small table for heavy milling on small components. The power employed is therefore related to the workpiece and not to machine table size, and milling heads of different sizes can be fitted to the same machine. The economic advantages of this system of construction are therefore extended into actual operating, saving power and floor space.

Some of the most commonly used arrangements are shown opposite. There is a catalogue available which gives full details. Write for a copy now.

Hickman LIMITED

ELECTORED MACHINE TOOL DIVISION, FLETCHAMSTEAD HIGHWAY, COVENTRY
Telephone: Coventry 60351

353 F82

THE ENGINEER

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NOTICE TO READERS
All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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USE OF BOX NUMBER: The charge is 2s. including the cost of re-addressing replies, which are forwarded immediately on receipt. N.B. There is no Charge for Box Nos. under "Situations Wanted."

WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

AUCKLAND UNIVERSITY COLLEGE

(UNIVERSITY OF NEW ZEALAND)

LECTURESHIP IN ELECTRICAL ENGINEERING

Applications are invited for a LECTURESHIP in ELECTRICAL ENGINEERING.

Candidates should be Graduates in Electrical Engineering. Experience in electrical measurements, transmission and distribution of electricity, or high frequency or line communication will be an advantage.

The salary scale for the position is from £800 to £950 per annum plus a recent general increase of £92 8s. per annum. Three annual increments of £50 are payable under this scale.

The successful applicant will be expected to take up his duties as soon as possible after appointment.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in New Zealand and London, is 15th October, 1954.

E5329

NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

SCHOOL OF ELECTRICAL ENGINEERING

SENIOR LECTURER IN ELECTRICAL ENGINEERING

Applications are invited for the above position. Salary £A1500 range £A1750 per annum. Commencing rate according to qualifications and experience. The successful applicant will be required to devote the major portion of his time to research in servo-mechanisms and will have only limited lecturing duties. Applicants must possess a Degree in Electrical Engineering, preferably with Honours, or a higher Degree. A knowledge of the theory of automatic control is essential and preference will be given to those applicants with research and/or practical experience in this field. The School is planning the installation of an electric analogue computer as an aid to the research. The appointee will be eligible, subject to medical examination, to contribute to the superannuation fund, which will provide an annual pension of up to £A1014 p.a. First-class shipping fares to Sydney of appointee and family will be paid. Six copies of applications together with six copies of testimonials and other supporting documents, should be lodged at the office of the Agent General for New South Wales, 56/57, Strand, London, W.C.2, by the 15th October, 1954.

E5267

THE UNIVERSITY OF LEEDS

DEPARTMENT OF ELECTRICAL ENGINEERING

LECTURER IN ELECTRICAL ENGINEERING

Applications are invited for appointment as LECTURER in ELECTRICAL ENGINEERING at a salary on the scale £550 by £50 to £1100 according to qualifications and experience. Applicants must have good academic qualifications and practical experience in the electrical engineering industry. Preference will be given to candidates whose interests are not confined to electronics. Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained), not later than 21st September, 1954. E5325

NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

SCHOOL OF ELECTRICAL ENGINEERING

LECTURER IN ELECTRICAL ENGINEERING

Applications are invited for the above position. Salary £A1100 range £A1450 per annum. Commencing rate according to qualifications and experience. The successful applicant will be required to devote the major portion of his time to research in servo-mechanisms and will have only limited lecturing duties. Applicants must possess a Degree in Electrical Engineering, preferably with Honours. A knowledge of the theory of automatic control is essential. The School is planning the installation of an electric analogue computer as an aid to the research. The appointee will be eligible, subject to medical examination, to contribute to the superannuation fund, which will provide an annual pension of up to £A1014 p.a. First-class shipping fares to Sydney of appointee and family will be paid. Six copies of applications, together with six copies of testimonials and other supporting documents, should be lodged at the office of the Agent General for New South Wales, 56/57, Strand, London, W.C.2, by the 15th October, 1954. E5268

EAST HAM COUNTY BOROUGH

EAST HAM TECHNICAL COLLEGE

ASSISTANT GRADE A

Required, January, 1955, ASSISTANT Grade A, for Electrical Engineering subjects, including Engineering Science and Electrotechnology for National Certificate, City and Guilds and Preliminary courses.

Burnham Technical Scale (London area).

Application forms (returnable 18th September) from Chief Education Officer, Town Hall Annexe, Barking Road, London, E.6. E5320

NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

NUFFIELD RESEARCH CHAIR OF MECHANICAL ENGINEERING

Applications are invited for the NUFFIELD RESEARCH CHAIR OF MECHANICAL ENGINEERING in the New South Wales University of Technology, Sydney. Applicants will be expected to direct and carry out research work in those fields of mechanical engineering which will contribute to Australia's full economic development. The University would be particularly interested in an applicant whose interests were related to the generation of atomic power. Salary £A2500. The appointee will be eligible, subject to medical examination, to contribute to the superannuation fund, which will provide an annual pension of up to £A1014 p.a. First-class shipping fares to Sydney of appointee and family will be paid. Six copies of applications, together with six copies of testimonials and other supporting documents, should be lodged at the office of the Agent General for New South Wales, 56/57, Strand, London, W.C.2, by the 29th October, 1954. E5269

UNIVERSITY COLLEGE OF SWANSEA

CHAIR OF CHEMICAL ENGINEERING

Applications are invited for appointment to the CHAIR of CHEMICAL ENGINEERING. Initial salary £1700 per annum wth superannuation and family allowances.—Full particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, to whom applications must be sent by Monday, October 25th, 1954. E5285

ELECTRICITY AUTHORITY OF CYPRUS

RESIDENT ELECTRICAL ENGINEER

Applications are invited for the appointment of a RESIDENT ELECTRICAL ENGINEER to supervise the construction by contractors of extensions to the Authority's 66kV. and 11kV. transmission network.

Candidates should be Corporate Members of the Institution of Electrical Engineers or hold qualifications exempting them from the Institution Examination, and must have had considerable experience in the construction of H.T. overhead lines up to 66,000 volts.

The appointment will be at a salary of £1250 per annum, plus a cost-of-living allowance, the present level of which is 15 per cent.

Free quarters with heavy furniture, or an allowance in lieu, will be provided by the Authority.

The appointment will be for a period of three years, terminable by three months' notice on either side.

Free first-class passages will be provided for the officer and his family up to three full passages, on first appointment, on termination of the agreement, and for long leave in the United Kingdom.

Home leave on full pay is earned at the rate of 2½ days per month of residence in service.

Applications, endorsed "Resident Electrical Engineer, Cyprus," stating age, qualifications and experience, should be forwarded within 14 days of the date of this advertisement to the undersigned, who will communicate with candidates selected for further consideration.

PREECE, CARDEW AND RIDER.
8–12, Queen Anne's Gate,
Westminster, S.W.1. E5271

SURVEYOR OF SHIPS (ENGINE AND SHIP)

HONG KONG GOVERNMENT MARINE DEPARTMENT

SURVEYOR OF SHIPS (Engine and Ship) required by the Hong Kong Government Marine Department, on probation for pensionable employment. Normal tour 4 years. Salary scale (including expatriation pay and present temporary allowance at rate for single men) equivalent to £1443, rising to £2109 a year. Additional temporary allowance £147/£211 a year (married men) and £295/£423 (family men). Commencing salary according to age and war service. Free passages. Liberal leave on full salary. Candidates should hold an Extra First Class M.O.T. Certificate, or a University Degree in Engineering (or equivalent technical qualification), plus a First Class Steam and Motor M.O.T. Certificate. Alternatively, candidates holding a First Class Steam and Motor M.O.T. Certificate and having experience ashore as Surveyor, Superintendent Engineer, &c., will be considered.—Write to the Crown Agents, 4, Millbank, London, S.W.1, State age, name in block letters, full qualifications and experience, and quote M2A/30670/EH.

E5333

BRITISH TRANSPORT COMMISSION

ASSISTANT TO CIVIL ENGINEER

British Transport Commission invite applications for the appointment of an ASSISTANT TO CIVIL ENGINEER, Barry Docks, South Wales, starting salary £900 per annum.

Candidates must be Chartered Civil Engineers with good experience in the design and construction of general civil engineering work, knowledge of maritime structures, capable of supervising the preparation of estimates of cost, contract drawings and documents.

The selected candidate will be required to join, if eligible, a contributory superannuation scheme of the Commission. Applications, stating age, experience and qualifications, should be sent to the Staff and Establishment Officer, 22, Dorset Sq., London, N.W.1. not later than 30th September, 1954. E5312

BRITISH ELECTRICITY AUTHORITY

LONDON DIVISION

CIVIL ENGINEERS

CIVIL ENGINEERS (3rd Assistant) (Vacancy No. 54/506) required for work on design and construction of power stations. Applicants should be suitably qualified with some years' experience of power station construction and administration of contracts. A knowledge of the design of steel and reinforced concrete structures and general civil engineering works is essential, and the practical application of soil mechanics principles would be an advantage. Salary in accordance with N.J.B. Agreement, Schedule C, Class AX/EX, Grade 4, within range £801 3s./£1053, and Grade 5, within range £681/£927 3s. p.a., inclusive of London Allowance.

CIVIL ENGINEERS (Junior) (Vacancy No. 54/507), required for training in general civil engineering work connected with the construction and maintenance of power stations. Applicants must have Higher National Certificate in Civil and/or Structural Engineering and have good knowledge of theory of structures and applied mechanics. Salary in accordance with N.J.B. Agreement, Schedule C, Class AX/EX, Grade 9, within range £415/£618 9s. p.a., inclusive of London Allowance.

Applications, quoting vacancy number, may be made on form obtainable from Divisional Secretary, British Electricity Authority, London Division, P.O. BOX No. 136, Generation House, Great Portland Street, W.1, and be received within 14 days of this advertisement. E5323

ADMIRALTY

ENGINEER OFFICERS IN ROYAL NAVY

A good career is offered to young men as ENGINEER OFFICERS, with permanent commissions, in the Royal Navy. There are three methods of entry :—

(1) Through the Britannia Naval College at Dartmouth. Competitive examinations are held in February, May and October, for entry in the following September, January and May, respectively. Candidates must be between 17 years and 8 months and 19 years of age on the first day of the month of entry.

(2) From University Graduates with a suitable Engineering or Science Degree. Candidates must be under 25 years of age on the 1st July for entry in the following September. Extensions may be allowed where the University course has been delayed by National Service.

(3) From National Servicemen who become Engineer Officers, R.N.V.R., and who are considered suitable for permanent commissions.

Engineer Officers specialise in marine, ordnance or aeronautical engineering and are trained to Degree standard. Their duties cover design development and research work as well as the operation and maintenance of equipment. There is practically no branch of mechanical engineering which is not covered by the three specialisations.

For further details apply to :—

The Secretary of the Admiralty, N.C.W. Branch, Queen Anne's Mansions, London, S.W.1. E5324

THE ELECTRICITY CORPORATION OF NIGERIA

ELECTRICAL AND MECHANICAL ENGINEERS

The Electricity Corporation of Nigeria has vacancies for :—

(a) ELECTRICAL ENGINEERS,
(b) MECHANICAL ENGINEERS,

for service in Nigeria.

Corporate Members of the Institutions of Electrical and/or Mechanical Engineers are invited to apply. Applications for a limited number of vacancies will also be considered from men with good practical experience possessing the Higher National Certificate.

Commencing salaries range from £760 to £1300 per annum, according to qualifications, age and experience, plus generous Expatriation Allowance. Pensionable or contract terms are available, the latter carrying an increase in basic pay and a gratuity at termination of service.

Free passages are provided for man and wife with assisted passages or U.K. maintenance allowance for two children up to 18 years of age. Furnished quarters at low rental, free medical attention, low income tax, home leave on full pay.

Forms of application can be obtained from the Liaison Officer, 11, Manchester Square, W.1.

E4591

HALIFAX AREA HOSPITALS MANAGEMENT COMMITTEE

GROUP ENGINEER

Applications invited for post of GROUP ENGINEER, to be responsible for operation and co-ordination of engineering services, including staff of tradesmen, for a group of seven hospitals in the Halifax and Todmorden areas. Candidates must be apprentice or otherwise suitably trained in mechanical engineering with practical experience of boiler plants, steam, water service, and electrical maintenance work. Possession of one of the following certificates is essential : Higher National Diploma or Certificate in Mechanical Engineering, Diploma in Mechanical Engineering of a recognised technical college, Extra First Class or First Class Certificate of Competency in Marine Engineering or equivalent Naval Certificate. Post vacant September, 1954. Salary scale, £775, rising to £880 per annum subject to superannuation. Applications, stating age, training, qualifications and experience, together with the names and addresses of three persons to whom reference may be made, to be forwarded to the Group Secretary, Royal Halifax Infirmary, Halifax, by 13th September, 1954. E5314

MUNICIPALITY OF KUALA LUMPUR, MALAYA

ASSISTANT ENGINEER

Applications are invited for the post of ASSISTANT ENGINEER in the Kuala Lumpur Municipality on 3 years' probation for admission to permanent establishment.

The salary will be within the range of $528 to $852/912 by $36 to $1200 per mensem commencing salary will be according to qualifications and experience.

Additional allowances for cost of living and patriation are payable, making a gross salary

For a single officer, of $870 to $1500.
For a married officer, of $1029 to $1785.
For a married officer with child, of $1094 to ($1 = 2s. 4d.)

Applicants should preferably hold a Degree or be Corporate Members of the Institution of Civil Engineers or the Institution of Municipal Engineers, but experience in the type of work carried out by a Municipal Engineer's Department, especially in connection with sewerage schemes, will be taken into consideration.

Free passage for the successful candidate, wife and family, will be provided and furnished quarters at a rental of approximately $40 per month.

Contributions at the rate of 10 per cent of basic salary plus expatriation allowance are made to the Council's Provident Fund and an equal amount will be donated by the Council.

Home leave will be allowed at the rate of 1 day per month of resident service after completion of 2 years.

A transport allowance will be paid.

Applications in duplicate, giving full personal and technical information, with copies of 3 testimonials also in duplicate, to Messrs. Allen and Wilkinson, 9, Victoria Street, London, S.W.1, before Wednesday, 8th September, 1954.

BRITISH ELECTRICITY AUTHO

HEADQUARTERS

3RD ASSISTANT ENGINEER (BOILER PLANT)

British Electricity Authority, Headquarters, London, require a 3rd ASSISTANT ENGINEER (Boiler Plant) in the Generation Plant Design Branch. Duties will be to assist in technical investigations in relation to boiler plant, with particular reference to combustion, heat transfer, corrosion and stressing problems, and in the preparation of specifications.

Candidates should preferably have a Degree in Mechanical Engineering or equivalent qualification and experience in the manufacture of major items of power station mechanical plant, preferably those associated with boilers. Salary, N.J.B. Grade A, £753 to £981 p.a., inclusive. Forms from Director of Establishments, Winsley Street, London, W.1, to be completed and returned by 20th September, 1954. Quote Ref. ENR/513.

NATIONAL COAL BOAR

TRACTION ENGINEER

National Coal Board invite application for superannuable appointment as a TRACTION ENGINEER on the staff of their Production Department in London. The successful candidate will be required to undertake traction work employing a wide range of difficult but interesting problems on the surface and underground, throughout the coalfields. Applicants must have good technical qualifications and must be capable of carrying out responsible work on projects, design, development and testing. Considerable experience with traction is necessary, particularly with the larger sizes of diesel locomotive.

Salary will be in the range £1100 to £1 annum, according to qualifications and experience.

Write, giving full particulars (in chronological order) of age, education, qualifications and experience (with dates), to National Coal Board, Establishment (Personnel), Hobart House, Grosvenor Place, London, S.W.1, marking envelope TT/823. No testimonials should not be forwarded. Closing date 5th October, 1954.

BRITISH TRANSPORT COMMISSION

ENGINEERING ASSISTANT (C

British Transport Commission invite ap for an appointment as ENGINEERING ASSISTANT (Civil), Barry Docks, South Wales, salary £820 per annum.

Candidates should be Chartered Civil Engineers with experience in design and construction of civil engineering works, knowledge of maritime structures, estimating of costs and preparation of contract specifications and documents.

The selected candidate will be required to join, if eligible, a contributory superannuation scheme of the Commission. Applications, stating age, experience and qualifications, should be sent to the Establishment Officer, 22, Dorset Square, London, N.W.1, not later than 30th September, 1954.

LANCASHIRE COUNTY CO

COUNTY SURVEYOR'S DEPART

ASSISTANT BRIDGE ENGINE

ASSISTANT BRIDGE ENGINEERS in the County Surveyor's Department. Salary £735 to £810, or £785 to £860, according to experience.—Particulars and application forms obtainable from the County Surveyor, County Hall, Preston. Closing date 17th September.

THE ENGINEER

SEPTEMBER 3, 1954

Agricultural Machinery Operation and Maintenance

THE City and Guilds of London Institute has issued a booklet setting out the regulations and syllabuses of courses in agriculture and agricultural engineering subjects which are being made available in the 1954–55 session. An exploratory committee was set up some time ago to make recommendations for such courses. Following this committee's suggestion, the City and Guilds of London Institute has constituted an advisory committee on farm machinery operation, care and maintenance, under the chairmanship of Mr. Alexander Hay, and schemes have been drawn up for courses and examinations in agricultural mechanics' work, agricultural engineering fitters' work, and farm machinery operation and care. In connection with these schemes the Institute is collaborating closely with the Institution of British Agricultural Engineers, and the certificate awarded to successful candidates in the farm machinery operation and care examination will be issued jointly by the two bodies. An important factor in a mechanised agriculture is, of course, the efficient operation and maintenance of tractors, machinery and implements. The scheme which has been drawn up is therefore intended to meet the needs of farm workers who have some experience of operating agricultural machinery. It is designed to increase and broaden their knowledge of machinery principles and methods of construction, so that they will be able to operate machines intelligently and economically in the field and undertake normal routine care and maintenance. The course of part-time study envisaged as providing an appropriate preparation for the examination extends over a minimum of sixty hours. The scheme may also provide a suitable basis for a comprehensive and balanced course for agricultural apprentices and others attending part-time day classes.

British Association at Oxford

THE 116th annual meeting of the British Association for the Advancement of Science began on Wednesday evening in the Sheldonian Theatre, Oxford, and will continue until Wednesday next, September 8th. It is estimated that about 3000 people are participating in this meeting, which is the sixth of the British Association's annual assemblies to be held at Oxford since the Association's foundation in 1831. The president this year is Dr. E. D. Adrian, O.M., P.R.S., who delivered his inaugural address on Wednesday evening. Dr. Adrian's subject was "Science and Human Nature" and excerpts from his address are printed on another page of this issue. The sectional meetings of the Association began on Thursday morning. Excerpts from Sir John Cockcroft's presidential address to the Mathematics and Physics section, which was entitled "Recent Developments in Nuclear Physics," are also given elsewhere in this issue. Dr. Willis Jackson, F.R.S., is the president of Section G, Engineering. His address, entitled "The Effect of New Materials on Engineering Progress," is being delivered this (Friday) morning.

Air Transport Advisory Council's Report

THIS week, the report of the Air Transport Advisory Council for the year ended March 31st last has been published by H.M. Stationery Office. It records that 118 applications were made during the year by air transport undertakings for permission to operate scheduled air services. In the period covered by the report, the independently operated air transport companies carried over 251,000 passengers, more than half the total being carried on international routes, principally on vehicle ferry services across the Channel. A foreword to the report has been provided by the former Minister of Transport and Civil Aviation, Mr. A. T. Lennox-Boyd. He says that the Government's air transport policy is aimed at combining the activities of the airways corporations and the independent companies in the way which will best serve the interests of British civil aviation and of all users of the services. Mr. Lennox-Boyd adds that although the results of the past year are not conclusive, they are none the less encouraging. He goes on to say that although the Air Transport Advisory Council was intended to be primarily a consumer council, the general public has taken little advantage of it to make representations on the adequacy of facilities or on charges. During the year dealt with in the report only one such representation was received.

Shipowners' Problems

A STATEMENT by Sir Ernest Murrant, chairman of Furness, Withy and Co., Ltd., which has been circulated with the company's annual report, comments on several of the problems at present confronting the shipping industry. In particular, Sir Ernest refers to the problem of replacement which, he says, is still acute and is likely to become increasingly difficult so long as the twin handicaps of excessive taxation and inflated shipbuilding costs exist. Sir Ernest goes on to say in his statement that for many years past, with one short-lived interval, shipowners have been obliged in their shipbuilding contracts to accept conditions not far removed from signing a blank cheque. Estimated costs, on which contracts have been based, have invariably been very substantially exceeded owing to increases in the price of materials and labour during the interval between contract and delivery. The burden of such increases, the statement asserts, has fallen upon shipowners, shipbuilders having shouldered very little, if any, of the risks involved in these one-sided arrangements. Sir Ernest suggests that the first step which shipbuilders can and should take as quickly as possible is to quote for orders on a fixed price basis. He believes that many shipbuilders realise the necessity for this first step "as a means of establishing a firm footing on which to base their efforts to stabilise prices, as distinct from the shifting sands which have hitherto frustrated their efforts in that direction." The second step, Sir Ernest urges, should be towards reducing costs by greater productivity, not measured by value but by increased effort, "whether by man, machinery or management." Greater productivity, the statement observes, if measured merely by value, and not by effort, might well be misleading and result in reduced effort and correspondingly increased costs.

Russia's Naval Forces

LAST week the Admiralty issued a statement containing an assessment of Russia's naval forces. The Admiralty thinks that in a short time, probably two or three years, the Russian Navy will comprise about thirty cruisers, 150 destroyers, 500 submarines, 500 motor torpedo boats, 1000 minesweepers, 300 escort ships, a number of patrol and landing craft, and about 4000 naval aircraft. In addition, the Admiralty says that a cruiser of the "Sverdlov" class can be built in two and a half years, and that an ocean-going submarine with an action of radius of 20,000 miles can be constructed in six months. Other information given in the Admiralty statement is that the Russian Navy has 750,000 officers and men, of whom about 270,000 are in ships and 85,000 in the naval air arm. The statement goes on to say that the Russian Navy may well be capable of using in varying degrees long-range torpedoes of a greatly improved design, mines with complex anti-sweeping devices, and tactical atomic weapons and guided missiles, both offensive and defensive. Furthermore, it is estimated that Russia is now devoting one-fifth of her total defence expenditure to naval forces. It is estimated that since the end of the second world war the equivalent of approximately £12,000 million has been allocated to the Russian Navy.

Fuel and Power Conference

A CONFERENCE of delegates from Chambers of Commerce throughout the United Kingdom is to be held at the Grand Hotel, Sheffield, on September 14th and 15th to discuss fuel and power supplies for industry. The conference is being arranged by the Association of British Chambers of Commerce, and one of the principal matters to be considered is the diminishing availability of coal and the increasing industrial demand for it. Fuel efficiency, the price of coal, and the use of alternative industrial fuels, all have a place on the conference agenda and will be debated by two groups of delegates concerned with both the policy and the technical aspects of those subjects. At the plenary sessions of the conference, addresses are to be given by Sir Hubert Houldsworth, chairman of the National Coal Board, Mr. D. Bellamy, chairman of the Yorkshire Electricity Board who will speak on "The British Electricity Industry," Mr. B. E. Vigers, of the Combustion Engineers' Association, who will deal with the economics of fuel efficiency in industry, and by Mr. L. Rotherham, of the United Kingdom Atomic Energy Authority, whose subject is to be "The Probable Contribution of Atomic Energy to Britain's Fuel and Power Problems." The conference chairman will be Mr. G. M. Flather, a past-president of the Sheffield Chamber of Commerce and chairman of the Association of British Chambers of Commerce fuel and power committee. Mr. Flather also serves on the board of the National Industrial Fuel Efficiency Service, the chairman of which, Air Marshal Sir Leslie Hollinghurst, will present prizes and certificates to successful candidates in the last boiler operatives examination at the final plenary session of the conference on September 15th.

Grants from the Road Fund

THE Ministry of Transport and Civil Aviation has circulated to all local highway authorities in Great Britain a comprehensive memorandum setting out the circumstances under which it is prepared to make grants from the Road Fund. The grants, which are "subject to the availability of funds," can be made towards approved expenditure on the major improvement of classified roads and of bridges carrying classified roads and on the construction of new roads, including any necessary bridges, which will merit classification when completed. Certain classes of expenditure on the regulation of traffic also come within the scope of the grants. The memorandum explains that a typical scheme of major improvement involves as its main factor one of the following descriptions of work: widening of an existing road, substantial widening of the carriageway within the existing road boundaries, improvement of a gradient, construction of a central reservation to provide dual carriageways, construction of a roundabout at a junction, widening, lengthening or replacement of a bridge by reconstruction beyond existing limits or to a strength exceeding its original strength, lowering of a road under a bridge or the raising of a bridge over a road to provide adequate headroom. The rates of grant applicable to approved expenditure on major improvements and new construction continue to be as notified in April, 1946, namely, 75 per cent for Class I roads; 60 per cent for Class II roads, and 50 per cent for Class III roads. Grants are not available towards expenditure on unclassified roads.

Some Notes on the Development of Fairground Machinery

By P. W. BRADLEY

No. VIII—(*Concluded from page 284, August 27th*)

To conclude the notes on fairground machinery the author deals with the road vehicles and prime movers used by travelling showmen for the movement from fair to fair of the amusement devices treated in previous parts. Showmen's generating equipment, and mechanical organs are also described.

PREVIOUS articles in this series having covered aspects of fairground machinery proper, consideration may now be given to the equipment used for its transport from fair to fair, and, where necessary, electric power supply. It has been seen that as far as is practicable riding machines are constructed to be dismantled into units small enough for man-handling, and that heavy indivisible components, such as steam centre engines, mechanical organs and electrically driven "centres" of modern machines are made so as to constitute towable road vehicles in themselves.

Generally speaking, components are packed either on open or in closed vehicles according to the protection they require. The conventional size of vehicle has varied somewhat over the years, for the reasons mentioned in the introductory article, and the numbers required have varied correspondingly. A modern truck, owner-built about eighteen years ago to carry various parts of a dodgem track, is shown in Fig. 30. By careful designing, a large number of light but awkwardly shaped pieces are secured in position with very little wastage of space. Capacious boxes beneath the main frame are also evident. Less obvious is the fact that the large eye of the V-shaped drawbar is upturned. Coupling is effected by inserting a "straight bar" (7ft or 8ft long, and having a small eye at each end) through the eye of the "vee-bar," and attaching it by means of pins to the frog's mouth couplings on the ends of the frames of the towing and towed vehicles. These couplings, provided at both ends of each truck, are strapped to the innermost pair of longitudinal frame members (in this instance of steel channel), and also spaced apart by a heavy timber beam running along the centre line of the vehicle. Consequently, when a train of such wagons is towed, the stresses, whether tensional or compressive, are transmitted straight through the train, and the risk of steering turntable failure through shear is eliminated.

Little more need be said about the ordinary packing truck. Six-wheeled examples are uncommon, and semi-trailers practically unknown. The showman's living wagon, although a subject for study in itself, does not include any features of particular mechanical interest. Its earlier history was ably chronicled in J. Harris Stone's *Caravanning and Camping Out*, an interesting old book unfortunately titled.

Attention may now be given to prime movers, other than those of roundabouts. An early application of steam power, now long obsolete, was the horse-drawn "electric light engine." Produced by various firms, but chiefly Savages, at first glance it resembled the "switchback" form of centre engine illustrated in Figs. 13, 14 of No. IV of this series. The cylinder block and crankshaft were transposed, the gearing and cheese wheel omitted, and a dynamo fitted at the front end of the frame, where it could be driven by a flat belt from the flywheel. A suitable awning, drop shutters and extension chimney were provided.

The use of steam power for showmen's road transport was uncommon until road locomotive design had become more or less stabilised—that is, in about 1895. Old photographs record that ordinary agricultural traction engines were used on occasions, and R. H. Clark's *Chronicles of a Country Works* establishes that Burrells supplied a new engine to a showman as early as 1889, but it seems that the splendid qualities displayed by various makes of engine during the Boer War finally convinced showmen generally that these machines could be of immense value in their business. By about 1904, they were being adopted in quantity and so suited the showman's needs that for heavy loads the internal combustion engined vehicle did not effectively challenge them until the early '30s. Nevertheless, about eighty survived in use until the end of the recent war, and in certain parts of the country one can still find a working example.

Fig. 30—Example of packing a "Dodgem" truck in a vehicle using the minimum possible space

Unlike other fairground machinery, the steam road locomotive has attracted the attention of various technical writers in recent years. Books to which the interested reader may refer include *The Traction Engine*, 1842–1936 (F. H. Gillford); *Traction Engines Worth Modelling* (W. J. Hughes), and *Chronicles of a Country Works* (R. H. Clark). The first covers briefly but completely the history of the development of the traction engine; the second describes some of the finalised designs in more detail, and it devotes a chapter to the Fowler showman's engine. It is not by any means confined to model-making interests. The last, the most ambitious, deals with the firm of Charles Burrell and Sons, Ltd., of Thetford, and is of value chiefly for its numerous illustrations. The three builders of road locomotives whose products found most favour among showmen were Charles Burrell and Sons, Ltd., of Thetford; John Fowler and Co. (Leeds), Ltd.; and Wm. Foster and Co., Ltd., of Lincoln. All three built fully fitted showmen's engines in various sizes, and in the case of the largest, either with or without special "scenic" fittings. Additionally, some showmen purchased haulage engines of these or other makes at second-hand and had the dynamo bracket, long awning and ornamental fittings added. Except in very early days, single-cylinder engines were rarely used by showmen. Two-cylinder compounds were the rule, all double-cranked except for certain earlier Burrell examples, whose high and low-pressure piston-rods were attached to a common crosshead. For showmen's engines Burrells always favoured outside slide valves, and one intermediate shaft between crankshaft and hind axle. Fowlers and Fosters fitted slide valves with inclined faces above the cylinders, the eccentrics being accommodated between the two cranks. Two intermediate shafts were provided in these makes. There were many other differences; final drive and differential gear layout, hind axle springing, gear-changing arrangements, boiler feed equipment and numerous other features differed appreciably between the various makes, and the subject is too vast for detailed treatment here. Other firms whose larger engines were put to fairground use included Wallis and Steevens, Ltd., of Basingstoke; Aveling and Porter, Ltd., of Rochester; J. and H. McLaren, Ltd., of Leeds; R. Garrett and Sons, Ltd., of Leiston, Suffolk; Fodens, Ltd., of Sandbach, and Ransomes, Sims and Jefferies, Ltd., of Ipswich. Most of these concerns built fitted showmen's engines to order.

The showman's engine differs essentially from a haulage engine only in the provision of a dynamo, usually of from 25kW to 35kW capacity and mounted on a bracket fitted to the smokebox. These machines were wound to supply the standard 110V d.c. at about 700 r.p.m. Direct drive by flat belt from the flywheel was universal. Fig. 31 illustrates a typical "Foster," built in 1919 and converted to a showman's engine some fifteen years later. The positions of the two intermediate shafts are clearly apparent, and the

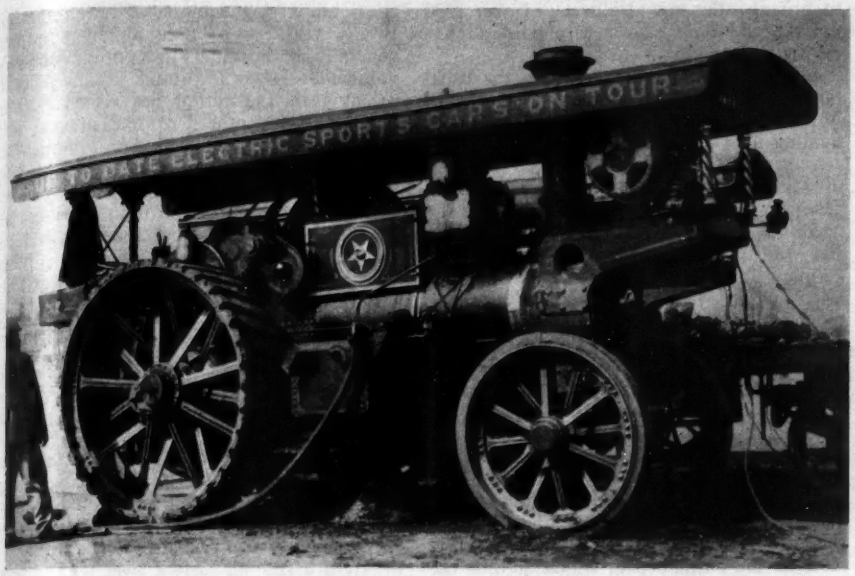

Fig. 31—A 7 m.p.h. steam road locomotive built in 1919 by William Foster and Co., Ltd.

small gear case extending forward and downward from the crankshaft accommodates the feed pump reduction gearing. The cylinders were of 6in and 9½in bore with a stroke of 12in. The hind wheels were 6ft 6in in diameter (over the original steel strakes) and the flywheel 4ft 6in. Three road speeds were provided (2, 4 and 6 m.p.h. at 250 r.p.m. of the crankshaft), and the makers described the engine as capable of hauling 23 to 25 tons gross load in the medium gear up a gradient of 1 in 20 on a good road. The weight was 12¾ tons, empty and without showman's fittings.

The special requirements of the Electric Scenic Railway were met by "scenic type" engines, which the three principal manufacturers supplied. The first difference was that the dynamo was separately excited by a second, smaller d.c. generator accommodated between the cylinder block and chimney of the Burrell and Foster and (usually) on the "off" side of the front water tank of the Fowler. It was belt driven from the armature shaft of the main dynamo, and enabled the heavy current taken by the eight 5 h.p. motors to be controlled by a small variable resistance on the cashier's desk. The other special need of the Scenic Railway was a high-lift jib crane with a capacity of about 25 cwt. Fig. 32 shows a "Scenic" car being railed by a Fowler engine so equipped. The normal hind axle winding drum of the engine was used, necessary extra guide pulleys being provided at the foot and head of a vertical hollow steel column permanently attached to the bunker. When the crane was in use, the head of the column was tied to the rims of the hind wheels by chains, one of which is just visible in the illustration. The crane jib could be slewed manually from ground level by means of a rope; a second engine was used to move the car truck into position for each lift. Other items of interest shown are the exciter on the engine fore tank, and the compensating and live rails of the scenic railway track. Most Burrell and Foster scenic type engines, together with a few later Fowlers, had a plate-built crane structure amounting to an upward extension of the bunker, instead of the column. In all cases the jib foot was securely packed from the ground before commencing lifting operations; Foster examples often had a special bracket to simplify this operation.

At a very early stage—in 1880, in fact—Frederick Savage devised and patented an arrangement whereby a traction engine replaced the portable centre engine of a roundabout. A steel tower was built as an upward extension of the main homplates to support the cheese wheel at the appropriate height, and bevel gearing and a vertical shaft transmitted the drive to the lantern wheel pinion. When the engine was in use in the roundabout, the normal chimney was blanked off, gases and exhaust then being diverted through an inclined flue passing above the motion to the centre "pole." Savages built a number of these engines, both single cylinder and double, and the experiment was tried on other makes; but although it was applicable to most of the older forms of roundabout and circular track machine, the "traction-centre," as it was known, does not seem to have been adopted very widely.

The little brother of the steam road locomotive, the steam tractor, enjoyed a good deal of popularity among showmen. Manufactured by a variety of firms, it amounted virtually to a three-quarter-sized edition of the road locomotive, and weighed empty 5 or 6 tons. It admirably suited the needs of the smaller showman, but several larger concerns operated one or two as auxiliary units. They were frequently equipped with dynamo and the other usual fittings. One, a Burrell, survived in regular fairground use until the end of the 1950 season.

Showmen also made extensive use of steam wagons fitted with locomotive boilers, the ubiquitous Foden being the most usual choice, but the rather similar Aveling and Porter, Burrell, Clayton and Shuttleworth, and Foster equivalents were also seen. Foden and others did on occasions supply new steam wagons to showmen, complete with dynamo in the customary place. Otherwise, it was generally fitted in the body and driven from the flywheel by a belt passing through a slot in the back of the cab. Like the tractors, these machines were to some extent used by roundabout proprietors as well as smaller showmen; one 6-ton Foden, for example, carried the platform, steps and gantry of a three-abreast "gallopers" and towed the centre truck, besides being responsible for the lighting of the machine. Halfway between the steam wagon and steam tractor was the Foden chain-driven tractor, at first sight a shortened edition of the wagon with additional fuel and water capacity replacing the body, but actually having larger road wheels, a winding drum on the hind axle, and generally being of heavier construction. It weighed, empty, about 8 tons. At least two were supplied new to showmen and had dynamos and extended awnings from the outset.

The petrol-engined lorry gained rapid popularity among smaller showmen during the years following the first world war. The addition of a generator did not as a rule present any difficulty; it was at that time generally fitted in the cab on the non-driving side, and connected by chain or belt to the engine flywheel. Some of the early petrol lorries were remarkably long lived; several purchased by showmen at surplus sales after the first world war survived until the second. Of obvious value to showmen, and very widely used, were Tilling-Stevens petrol-electric vehicles. It was not until the '30s, however, that roundabout

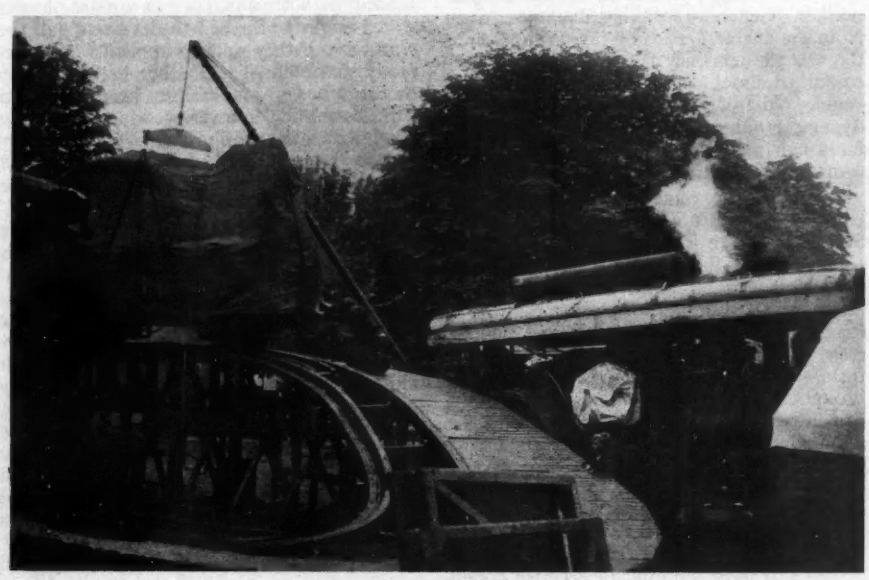

Fig. 32—An Orton and Spooner "Dolphin and Neptune" scenic railway being built. A Fowler road locomotive with "high-lift" jib crane is being used to transfer the cars (weighing upwards of a ton) from road wagon to track

proprietors adopted motor tractors. Heavy diesel (or sometimes petrol) lorry chassis were used ; in the case of the " dead axle " chassis, with independent final chain drives, the dynamo was fitted across the chassis and driven by alternative lighter chains. Those having a " live " rear axle generally had the dynamo placed with its armature shaft parallel with the frame and driven by multiple V-belts from the power take-off. Rather later, an arrangement somewhat resembling that of a fire pump was often adopted. The dynamo was fitted at the extreme rear of the chassis between or beneath the frame members, and coupled to the gearbox by an alternative longer cardan shaft. By 1938–39, tractors of one or other of these forms were quite numerous ; generally, however, they were attached to new riding machines and the steam showman's locomotive was still a common sight.

In pre-war years there were produced two diesel-engined tractors specifically designed for the showman's needs. The first was built by Fowlers of Leeds in 1935. It retained the 6ft 6in diameter solid rubber-tyred hind wheels of the steam locomotive, but the front wheels and steering gear, engine bonnet, and cab resembled those of a heavy motor lorry of the period. An 80 b.h.p. engine drove the rear wheels through a choice of eight gear ratios. The 500A dynamo was driven straight through the gearbox at engine speed. The second was built in 1938 by Scammell Lorries, Ltd., and was of more conventional outline, essentially resembling the motive unit of the articulated multi-wheeled lorry of that firm's design. Alternative double-chain drives were provided to rear wheels and to the dynamo—a Mawdsley 300A machine mounted on an iron ballast block over the rear axle. The power unit was a six-cylinder Gardner oil engine driving through a four-speed gearbox.

This Scammell product was reintroduced with improvements in 1946, and a number have since appeared on the fairgrounds. In the post-war design, shaft drive to a " live " hind axle replaces the former chains, and the dynamo (still of Mawdsley manufacture, but rated at 450A) is now driven by multiple V-belts. A winch is another valuable addition. Post-war innovations in showmen's motive power otherwise consist predominantly of heavy vehicles, often of American design, purchased on the surplus market. Generally speaking, dynamos driven from the engine are losing favour, and since the war the tendency has been towards self-contained diesel generating sets consisting of engine, radiator, fuel tank and direct-coupled dynamo mounted on a bedplate. Two such units can readily be mounted on a " tank transporter " motive unit.

Many of the remarks in the foregoing paragraphs are not wholly applicable to Scotland, where riding machines identical to those used further south have to travel an average of 50 miles or more between fairs. The steam road locomotive era was as long-lived as in England, but the change-over, when it came, generally took a different form. Load-carrying diesel lorries were brought into use, rather than tractor units, and fitted with flat, framed or van bodies as required. Each would pull one packing vehicle, centre truck or living wagon, and shaft-driven dynamos were fitted at the rear of the lorry chassis. The use of load-carrying, self-propelled vehicles theoretically means a less flexible transport system, but in practice it seems to meet the difficult Scottish conditions admirably. Six large Scottish machines visited London at the time of the recent Coronation celebrations and a seventh went to Bristol ; this round journey of over 1000 miles would have been a formidable undertaking with tractors.

Electrically, it has always been the usual fairground practice to couple each generator, however driven, directly to its power and/or lighting load ; the paralleling of generators is very rarely attempted. There is, however, in service one example of a large mobile generating plant of capacity sufficient for the needs of an entire fairground of average size, and in this instance three dynamos are coupled in parallel to common busbars. Each has an overload cut-out and a voltage regulator for adjusting the load distribution. The basis of this unit is a Foden rigid eight-wheeled lorry chassis powered by a Gardner six-cylinder diesel engine. When the vehicle is stationary, this engine drives a 50kW dynamo. The other two generators, each of 100kW, are direct driven by 150 b.h.p. Ruston and Hornsby diesel engines. These units are mounted on the chassis, the engines being positioned above the rear bogie with the generators forward of them, and conveniently close to the switchboard, which adjoins the driving cab. At the rear end are the engine radiators and a small workshop, and fuel is carried in overhead tanks. Lang Wheels, Ltd., was responsible for the design of the outfit ; Lancashire Dynamo and Crypto, Ltd., supplied the generators, and Foster Transformers and Switchgear, Ltd., the control equipment.

Showmen almost always have to be self-reliant in the matter of electricity supply, but in special circumstances, such as when, during the recent war, a fair sometimes remained on a site for a period of months or even years, it became economic to purchase a supply. In such instances, a suitable motor was obtained and coupled (usually by belt) to a standard 110V d.c. generator.

Finally, brief reference may be made to fairground music. The mechanical organ has to a large extent been replaced by electrical amplifying equipment during the last twenty years or so and, among showmen generally, extraordinary ideas of the necessary volume level seem to prevail. Many times in recent years the author has visited fairs in company with others of like interest and found ordinary conversation impossible. The general use of " vocal " records is equally inexplicable. Mechanical organs operated at a volume comfortable both to riders on the machines and to bystanders, but their pleasant and unmistakable tone had a habit of travelling with the wind over considerable distances. There seems to be no reason why electrical amplification equipment should not be operated at a similar volume level ; in fact, in instances when this is done, the remarkably true rendering of which modern equipment is capable is something of a revelation.

The mechanical organs were imported from the Continent. The valve controlling the wind supply to each pipe was pneumatically operated from a " key frame " consisting of from sixty-five to 112 brass tongues projecting from a smooth surface over which there passed a folding cardboard music sheet. The cardboard normally held the keys flush with the surface ; a hole or slot in the cardboard permitted the appropriate key to rise, so causing that pipe to speak for a definite period. Percussion effects, the miniature conductor's arms and head and, in some cases, mercury switches to control special lighting effects, were similarly actuated. Propulsion of the cardboard music through the key frame was by means of a pair of rollers, one of which (together with the bellows crank-shaft) was driven by either steam or electric power. Some of these organs were magnificent instruments, and Sunday recitals in aid of local charities were given in various parts of the country. A number, mostly of the smaller patterns, are still in use ; in fact, there has been some revival of interest in them since the war.

British Association

No. I

SCIENCE AND HUMAN NATURE*

By Dr. E. D. ADRIAN, O.M., P.R.S.

We all know where our curiosity has now landed us, with advances in atomic physics which might be applied to devastate half the world and if they were so applied would certainly make life in the other half extremely precarious. Our grandfathers here were faced with scientific discoveries which were no laughing matter, for to many of them they spelled the end of all worthy human aims,† but we face discoveries which might spell the end of all human aims, worthy or not.

We can regret that atomic bombs are possible, without regretting the discoveries that have led to them. Advances in natural science cannot avoid advancing the methods of warfare ; they do so when they make armies more healthy as well as when they increase the power of their weapons. But although the strategists have to think mainly of immense explosions and great devastation, it would be a mistake to suppose that these are the only dangers. Even if we can survive then we must face the possibility that repeated atomic explosions will lead to a degree of general radio-activity which no one can tolerate or escape.

The level would not rise rapidly and there is a large margin in hand, but the physicists can estimate the persistent contamination which must follow an atomic explosion of a given magnitude and the biologists can assign limits to the amount of contamination which could be let loose on the world without serious danger to every part of it. When atomic energy is used to supply power for industry the dangers of contamination are real enough, but due precautions can be taken to avoid them. In a major war they would soon be set aside. Powerful nations who think they could win quickly might accept the risk. A few hundred large bombs would not raise the level of radiation to the point where it would become a general danger, and no doubt a country of small area like ours could be reduced to ashes by a relatively small mass of explosion. Though the ashes would be deadly, the rest of the world might escape them. But a long war between powers well armed with bombs would certainly involve an order of radio-active contamination which would involve us all, victors as well as vanquished.

We are afraid, and rightly, because we cannot trust ourselves to act peaceably, because we know that unless we are ready to give up some of our old loyalties we may be forced into a fight which might end the human race. Our predicament is the inevitable result of our curiosity and of the

* Excerpt from the presidential address to the British Association for the Advancement of Science, Oxford. September 1, 1954.

† Dr. Adrian referred earlier in his address to the shock created by Darwin's evolutionary theory.

physical nature of the world we live in. The scientist, therefore, has a double responsibility. He must apply his science to learn as much as possible about the mental and physical causes which make us behave as we do, he must study human nature to prevent its failures ; but he cannot wait for the discoveries which might make us act more wisely ; he must take us as we are and make it his task at meetings like this to point out that the human race cannot stand more than a few thousand large atomic explosions whether they hit their target or miss it. If we can make this known universally our Association will not have failed in its purpose.

It may be optimistic to think that our dangers would recede if we had a better understanding of human reactions : in fact, if we must continue to make war there is no kind of scientific investigation which might not be used to make it more effective and there can be no guarantee that discoveries in the field of human conduct would be harmless. A drug or a system of education which would make us all do as we are told, a method of producing radical conversion to a new system of belief, a knowledge of new ways of rousing patriotic ardour, all these might be used with consequences almost as grim as the genetical deterioration in a radio-active world. The psychiatrist who discovers a cure for paranoia may find that he has also revealed a convenient way of producing it.

We can only be protected from radio-activity by living in caves on uncontaminated food and drink, but an increased knowledge of how the mind can be influenced could certainly forestall many of the influences which might be used to undermine our integrity. It is certainly true that discoveries relating to our own nature may mean a painful readjustment of our beliefs : that, however, is a fair price for increased understanding.

RECENT DEVELOPMENTS IN NUCLEAR PHYSICS‡

By Sir JOHN COCKCROFT, K.C.B., C.B.E. F.R.S.

I ought not to close without saying something of the dangers and the potential benefits which have arisen from the exploitation of these powerful nuclear forces. The president has already spoken of the dangers which might arise from full-scale atomic warfare. The destruction and danger from heat and blast and radio-active fall-out in the immediate neighbourhood of the large explosions is by now apparent to all. Our Prime Minister has referred to the danger of world-wide radio-active contamination and has said that the biological aspects of these experiments require profound study. In this study we have to take account of the conclusions of the geneticists on the effects of radiation in increasing the natural mutation rate. Dr. H. J. Muller's 1952 address to the Stockholm Conference on Radiobiology and Radiation Protection has summarised the present views of geneticists and has suggested how much radiation the human race can tolerate without harm. The present contamination is slight and very far from this limit. Our measurements will in time tell us where the danger level lies.

What is certain is that a full-scale atomic war would be a disaster for the whole world. Our Prime Minister has spoken of our present situation as one of great danger and measureless opportunities. We must hope and believe that all governments will take the same view when they see the danger and unite to prevent it happening. If mankind can achieve this, then the great power of nuclear forces can be used to his great future benefit.

I have taken part almost from the beginning in the great adventure of atomic energy development. We had only just begun to think about the consequences of Hahn and Strassman's discovery of fission when war came upon us and for a time engulfed us in more immediate and practical matters such as radar. So, for a time, I was an interested onlooker, gradually becoming more and more convinced of its importance, until I was translated to Canada and joined the group who were starting to design the Canadian heavy-water piles. The larger of these piles became for a time the most powerful source of neutrons in the world. This has enabled the Canadian project to play a leading part, under the guidance of Dr. W. B. Lewis, in the development of nuclear technology. In this country, after building from the beginning in 1946 facilities for work on atomic energy, we have embarked during the last three years on a vigorous programme of nuclear power development.

The achievement of economical nuclear power depends on three main factors. The nuclear reactor must be able to burn up a sufficiently high proportion of its uranium fuel to achieve low fuel costs. This depends not only on favourable values of nuclear constants, but also on a reactor design leaving as many neutrons as possible for production of new fuel from otherwise inert materials such as U238 and thorium ; engineers who waste neutrons can easily offset the bounty of Nature. Nuclear technology is the second important factor. We must be able to prepare uranium fuel cheaply, and its metallurgical properties must be favourable to really long life in a reactor ; the chemists and chemical engineers must process our spent fuels cheaply and return any valuable secondary fuels such as plutonium for reburning. The third factor is good engineering design, leading to reliable and safe operation and low capital costs.

In all these fields we have seen steady progress, more favourable than we dared to hope for in the early post-war years. As a result of this, in Cumberland the first large-scale power station using nuclear energy as a source of heat is being built by our colleagues of the Atomic Energy Industrial Group, following a Harwell design study. This first nuclear power station has been described by Sir Christopher Hinton in his Thomas Hawksley Lecture to the Institution of Mechanical Engineers. Its design is an extrapolation of our post-war experience with graphite piles at Harwell and Windscale. It should provide us with invaluable first experience in practical nuclear power. We can already see our way to great improvements in nuclear power stations of this kind and they are likely to make an effective contribution in filling any gap which may arise in the next twenty years between our energy needs and our supplies and should be able to produce power a little above conventional costs. But we can also think of an embarrassingly large number of types of nuclear power units which should use nuclear fuel much more efficiently and which would repay investigation, and, of course, they look more attractive the farther off they are.

Energy is the essential basis for a highly developed civilisation. The application of nuclear fission, wisely guided, can ensure that for a millenium ahead mankind has all the energy needed to supply his ever-growing needs. Before we come to the end of our uranium fuel reserves, I feel sure that the energy of fusion of the light elements will also be turned from destructive to peaceful uses and so provide a source of power without limit.

(To be continued)

‡ Excerpt from the presidential address to Section A of the British Association for the Advancement of Science, Oxford. September 2, 1954.

"Nimonic" Alloys

DATA on the properties of "Nimonic 95" has been received from Henry Wiggin and Co., Ltd., of Birmingham. This alloy is a recent addition to the "Nimonic" series and an extensive survey of properties, particularly long-time creep properties, has not yet been possible. Nevertheless, a considerable amount of data is now available and is given by the firm, together with some extra information on "Nimonic 90."

The greatest creep resistance is normally obtained by solution treating the alloy at as high temperature as possible, but this can sometimes lead to the development of a coarse-grain size, depending on the conditions of the prior hot working. The recommended treatment which gives good creep properties and retains a fine-grain size over a wide range of hot working conditions is as follows :—Four hours at 1150 deg. Cent., air cool, followed by six to eight hours at 1080 deg. Cent., air cool, followed by sixteen hours at 700 deg. Cent., air cool.

After this treatment properties of the order shown in the accompanying tables have been obtained on "Nimonic 95."

Initial solution treatment for one to two hours at 1200 deg. Cent. has been used instead of four hours at 1150 deg. Cent. when a coarser grain size has not been regarded as unsatisfactory, the later steps of the treatment remaining unchanged.

TABLE I—*Fatigue Properties, Rotating Bend Test*

Alloy	Temperature, deg. Cent.	Stress, tons per square inch	Endurance
"Nimonic 90" ...	815 870	0±17·4} 0±12·2}	45×10^6 cycles in about 300 hours
"Nimonic 95" ...	870	0±20 0±16·8	10×10^6 cycles in about 65 hours 45×10^6 cycles in about 300 hours

TABLE II—*Short-Time High-Temperature Tensile Properties of "Nimonic 95"*

Property	Temperature, deg. Cent.										
	20	100	200	300	400	500	600	700	800	900	1000
0·1 per cent proof stress, tons per square inch ...	51·6	49·3	48·5	46·5	46·3	46·0	44·3	43·0	31·1	17·1	4·12
Maximum stress, tons per square inch	81·9	76·0	77·9	75·1	72·0	72·1	64·7	51·5	40·1	21·9	6·2
Elongation per cent on $4\sqrt{\text{area}}$	25·1	21·9	20·6	20·6	21·4	23·6	13·7	4·5	4·5	10·9	59·3
Reduction of area, per cent	24·1	25·5	21·9	24·6	25·3	28·1	19·5	7·1	6·4	12·5	48·0
Modulus, millions of pounds per square inch ...	30·5	29·8	30·6	29·3	29·3	27·3	26·4	25·1	22·0	17·9	14·1

TABLE III—*Creep Characteristics of "Nimonic 95"*

Temp., deg. Cent.	Stress (tons per square inch) to produce creep extension of																	
	0·1 per cent in				0·2 per cent in					0·5 per cent in				Rupture in				
	100 hours	300 hours	1,000 hours	5,000 hours	100 hours	300 hours	1,000 hours	5,000 hours	10,000 hours	100 hours	300 hours	1,000 hours	5,000 hours	100 hours	300 hours	1,000 hours	5,000 hours	
750	20	16·5	13	9·2	22	18	14·5	10	8	23	19·5	15·5	10·5	23·5	19·5	16	11	
815	11	8·5	6	—	12	10	7·5	—	—	13	10·5	8	—	13·5	11·5	8·5	—	
870	7	5	2·7	—	8	6	4	—	—	8·5	7	5	—	9	7	5·5	—	
925	—	—	—	—	—	—	—	—	—	—	—	—	—	5·0	3·8	2·2	—	

Machine Design for Cyclic Stress

By J. S. CASWELL *

No. I

The customary methods of machine design for static stress are unsatisfactory for the purposes of cyclic stress design. The characteristics and the effects of cyclic stressing are discussed and reference is made to the use of base diagrams for design purposes. The serious effects of stress concentration are considered and new formulæ are presented for use in cyclic stress design. These formulæ make provision for counteracting the effects of stress concentration and also for taking some account of the effect of a quality change between the fatigue test specimen and the service part. The value of the correction factor used may be altered to take account of the useful effects of special surface treatments of machine parts. The applications of the proposed methods of design are considered in relation to cyclic stresses which arise in direct loading, eccentric loading, bending, torsion, and combined bending and torsion. A few examples with detailed solutions are included to illustrate design procedure.

IN some educational courses, textbooks and examination papers, covering the important subject of machine design, it is not uncommon to find the same method of approach applied to a wide range of machine design without adequate regard for the type of stressing that occurs in the parts. The customary method of design for static stress conditions is unsatisfactory for varying stress conditions, and consequently there is a danger that some parts, designed on the basis of static stress design methods, may fail in service. Serious interruption of production may be brought about by the breakdown of machinery and it is very desirable that all the relevant foreseeable causes of machine failures should be borne in mind by all who are concerned with the design, manufacture and the use of machines. The principal requirements related to these are, respectively: safe maximum stresses, good-quality material and avoidance of overloading. A high degree of responsibility for the satisfactory service of a machine lies with the user, but the initial responsibility lies with the designer, and his task of ensuring safe maximum stresses is not always easy because the methods of design for machine parts subjected to continuously varying stress have not been as fully worked out and co-ordinated as for static stress design. The purpose of this article is to outline the general approach to the subject and to present some methods of design for machine parts subjected to cyclic stress.

Cyclic Stress

Cyclic stress refers strictly to that condition under which the stress in a machine part varies continuously between two stress values, but the term is more generally applied to any condition of continuously varying stress. Some examples of cyclic stress variations are shown in Fig. 1, where the stress limits are $+\sigma_1$ and $\pm\sigma_2$.

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Other diagrams of an opposite kind to (*b*), (*c*) and (*d*) could be drawn, so that the stress limits would be $\pm\sigma_1$ and $-\sigma_2$, and the diagram opposite to (*d*) would then show fluctuating compressive stress. The complete range of the limits of stress variation for some materials could be conveniently represented in a modified Goodman diagram (Fig. 2), which is typical of a wide range of diagrams for various steels, e.g. the diagrams produced by the Verein Deutscher Ingenieure, but for the purposes of general design procedure a simplified form of representation may be used and this is referred to later.

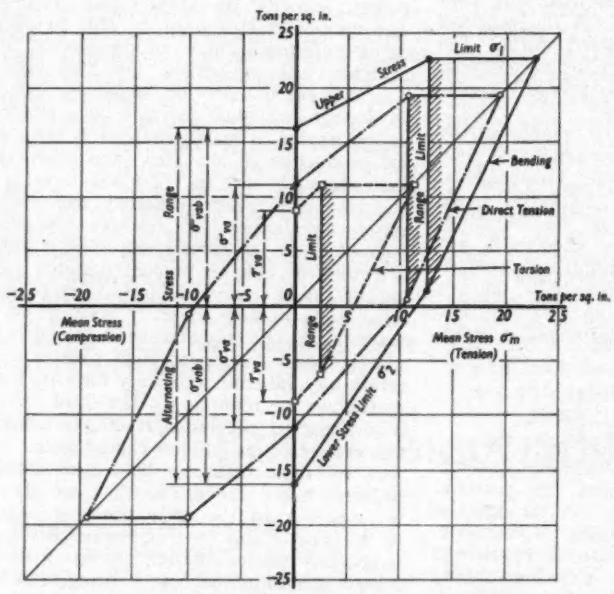


Fig. 2—A typical Goodman diagram for the representation of fatigue test data

The kind of stress variation can be defined by stating the values of two stresses, viz. the mean stress, σ_m, and the variable component of stress or the semi-stress range σ_v. These stresses are shown in Fig. 1 and their values, in terms of the stress limits, would be :—

$$\sigma_m=\frac{\sigma_1+(\pm\sigma_2)}{2} \text{ and } \sigma_v=\frac{\sigma_1-(\pm\sigma_2)}{2}.$$

The associated values of the mean stress σ_m and the limit of the semi-stress range σ_v, at which failure would occur under cyclic stress for a given set of conditions, provide important preliminary data for cyclic stress design purposes. Some endurance test results obtained on two different samples of 0·13 per cent C steel, tested by slightly different methods, have been plotted in Fig. 3. Other results for a wide range of steels, plotted on a slightly different basis, are given by Gough in his book *The Fatigue of Metals*, first edition, pages 75–76. It will be observed that although the results, when taken separately, could be represented by Gerber's parabolic law, the results taken together show some scatter and this, in the aggregates is a characteristic of lesser or greater degree in similar tests on other steels. A further point to observe is that the uppermost useful limit of the mean stress σ_m is reached when $\sigma_m=\sigma_p$, the yield stress of the material, or equal to σ_p, where σ_p is the proof stress. Moreover the semi-stress range σ_v must become zero when that limit of the mean stress is reached. Consequently a condition arises which suggests that for a given set of conditions the boundaries for the uppermost limit of the associated stresses σ_m and σ_v, for smooth, uniform diameter specimens of 0·13 per cent C steel could be approximately represented by the straight lines *AB* and *AC*. The right half of this diagram is the more important because machine part failures are almost wholly due to cyclic tensile stresses which exceed safe limits. Thus we arrive at the simple triangular figure *OAB* which was proposed originally, it seems, by Soderberg.[1] This could be called the base diagram for general cyclic stress design. The straight line *AB* cuts out a small amount of useful semi-stress range, but the use of a linear failure boundary provides a small initial margin of safety and it permits the formulation of simple expressions for important stress values.

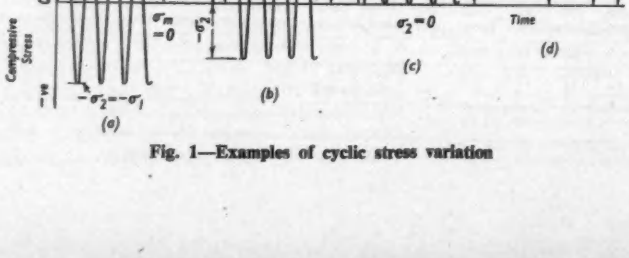


Fig. 1—Examples of cyclic stress variation

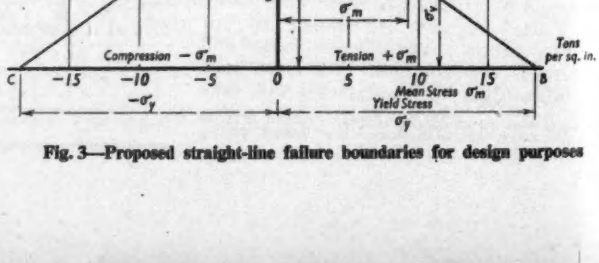


Fig. 3—Proposed straight-line failure boundaries for design purposes

For special purposes in design, modified linear base diagrams, represented by *OACBO* in Fig. 4, could be used. These diagrams could be drawn to give closer representation of endurance test results. Also see Fig. 19, to be reproduced and discussed at a later stage.

The Cyclic Stress Base Diagram

The cyclic stress base diagram *OA'C'B'* has much the same significance for cyclic stress design as the well-known load-extension

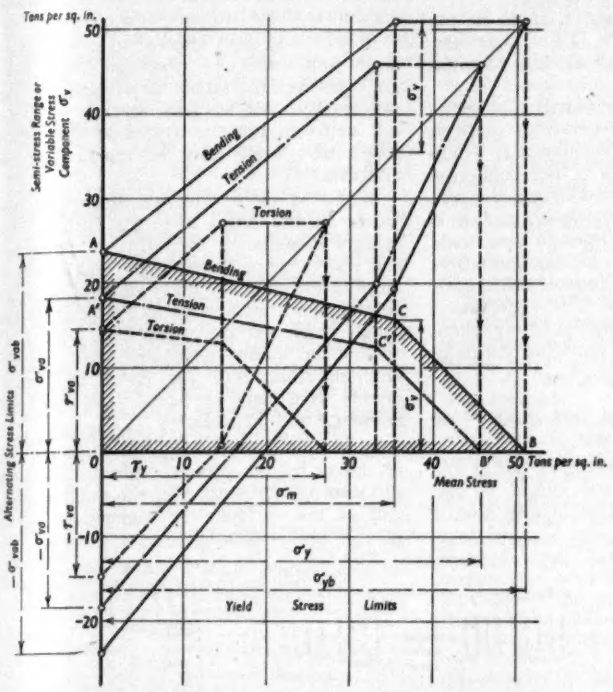


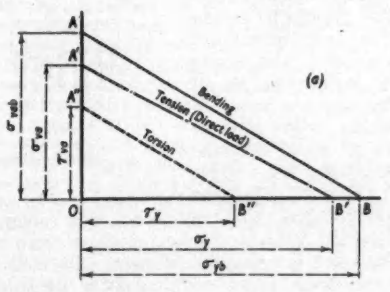
Fig. 4—Conversion of Goodman diagrams to the proposed modified or "knee" type base diagrams

diagram has for static stress design. Each diagram indicates the extreme boundary of the stress-carrying capacity of the material under given conditions, and shows two important critical points, viz. : the yield stress σ_y and the ultimate tensile stress σ_u, in the load-extension diagram, and the yield stress σ_y and the appropriate alternating stress fatigue limit σ_{yo}, in the cyclic stress diagram. The important difference in the diagrams is that the load-extension diagram may be obtained autographically during a tensile test whereas the cyclic stress base diagram must be constructed from a knowledge of the yield stress σ_y, the alternating stress fatigue limit σ_{yo} and the range limits, $\pm\sigma_v$, obtained respectively from a tensile test and a fatigue test of the material in a defined form and physical condition. Typical locations of straight-line failure boundaries for endurance tests on smooth, uniform diameter specimens, subjected to cyclic stress produced by bending, direct tension and torsion, are shown in Fig. 5 (*a*) by the lines *AB*, *A'B'* and *A"B"* respectively. The position of these failure boundaries should not be fixed until careful consideration has been given to the effect of factors which may affect the resistance to fatigue failure, e.g. the physical condition of the metal near the surface, the quality of the surface finish at the points of high stress, the size effect as between test specimens and the machine part, residual stress, &c. The effects on the yield stress value should also be considered. The general effect is to alter the position of the failure-line as shown by the lines *a'b'* and *a"b"* in Fig. 5 (*b*) according to the number, type and the magnitude of the effects. Careful location of the failure boundary or the incipient failure line is an important prime requirement in cyclic stress design procedure, If σ_{yo} is the alternating stress endurance limit for uniform diameter polished specimens, the failure-boundary for the machine part could be fixed by the stress σ_{yo}/γ where γ is the appropriate overall correction factor for the endurance limit referred to the machine part. When there is little difference between the physical condition of the specimens and the machine part, it could be assumed that the yield stress for the specimens remains the same for the machine part.

When grooves, perforations or fillets, &c., are present, special consideration must then be given to two additional factors, viz.: stress concentration and notch sensitivity. These important matters are discussed in a later section.

The Safe Working Stresses

The safe working stress boundary in the base diagram must be located with due regard for the margin of safety required, the uncertainty of overloading, the necessity of providing other qualities than resistance of the machine part to failure by fatigue, e.g. adequate stiffness, resistance to creep, economy of manufacture, &c. If the same factor of safety n is applied to the alternating stress endurance limit and the yield stress, the safe stress boundary is represented by a line *DE* drawn parallel to *AB* in Fig. 5 (*b*).



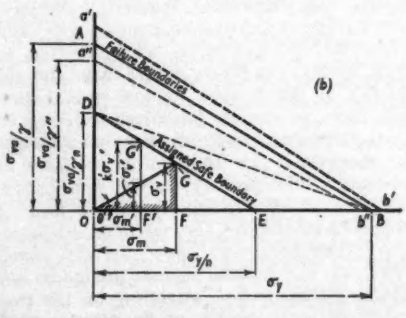
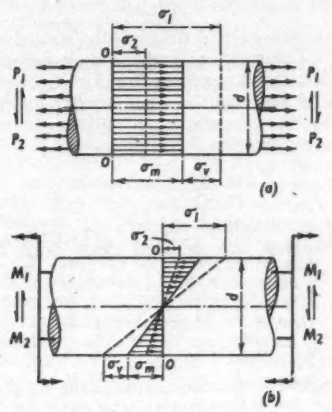


Fig. 5a—Base diagrams for bending, tension and torsion

Fig. 5b—Location of the safe-stress boundary line using a factor of safety n and a correction factor γ

Alternatively, a safe stress-boundary could be represented by the line *DB*. This would lead to higher stresses and lighter design, but the permissible fluctuation of stress with mean values close to the yield point may be an undesirable condition with the pseudo-elastic conditions near the yield point. Design procedure on this kind of diagram is outlined by Peterson.[2]

A wide choice in the location of the safe boundary line is open to the designer, but the parallel location is perhaps most convenient for general design purposes. Then, for a mean stress $\sigma_m=(OF)$, Fig. 5 (*b*), the permissible value of the variable component is $\sigma_v=FG$. The relationship between σ_m



(*a*) In tension $=(P_1-P_2)/(P_1+P_2)$
(*b*) In bending $=(M_1-M_2)/(M_1-M_2)$.

Fig. 6—Stressing ratio σ_v/σ_m

and σ_v depends on the value of what may be termed the stressing ratio, viz.: σ_v/σ_m and its value may be expressed in terms of the corresponding loading ratio as shown in the two cases below.

In case (*a*), *Fig.* 6.—The mean load

$$P_m=\sigma_m A=\frac{P_1+P_2}{2}\ (A=\text{cross-sectional area}).$$

The variable component of the load

$$=P_v=\sigma_v A=\frac{P_1-P_2}{2}.$$

Loading ratio

$$=\frac{P_v}{P_m}=\frac{\sigma_v A}{\sigma_m A}=\frac{(P_1-P_2)/2}{(P_1+P_2)/2}.$$

Therefore, stressing ratio

$$\frac{\sigma_v}{\sigma_m}=\frac{P_1-P_2}{P_1+P_2}$$

or more generally,

$$\frac{\sigma_v}{\sigma_m}=\frac{\pm P_1-(\pm P_2)}{\pm P_1+(\pm P_2)}=\tan\theta\ .\ .\ (1)$$

where θ is the angle subtended by σ_v in Fig. 5 (*b*). For direct compressive loads, it is assumed here that the bar is short and not subject to collapse by buckling.

In case (*b*), *Fig.* 6.—The mean bending moment

$$M_m=\sigma_m Z=\frac{M_1+M_2}{2}\ (Z=\text{modulus of the section}).$$

The variable component of the bending moment :—

$$M_v=\sigma_v Z=\frac{M_1-M_2}{2}.$$

Loading ratio

$$=\frac{M_v}{M_m}=\frac{\sigma_v Z}{\sigma_m Z}=\frac{(M_1-M_2)/2}{(M_1+M_2)/2}.$$

Therefore stressing ratio

$$\frac{\sigma_v}{\sigma_m}=\frac{M_1-M_2}{M_1+M_2},$$

or more generally

$$\frac{\sigma_v}{\sigma_m}=\frac{\pm M_1-(\pm M_2)}{\pm M_1+(\pm M_2)}=\tan\theta\ .\ (2)$$

When the appropriate base diagram is drawn and a line is drawn from the origin O with an angle θ, Fig 5 (b), the values of σ_m and σ_v are obtained directly. Then in the case of the round bar, Fig. 6 (a), the diameter d is given by :—

$$(\sigma_m+\sigma_v)\frac{\pi}{4}d^2=P_1 .$$

Therefore

$$d=\sqrt{\frac{4P_1}{\pi(\sigma_m+\sigma_v)}}$$

where P_1 is the maximum value of the varying load.

A Modified Expression for the Safe Mean Stress

The necessity of drawing the base diagram and measuring the angle θ may be avoided by deriving an expression for σ_m from the relation between the triangles BOA and EFG in Fig. 5 (b), in which $GF/FE=OA/OB$ or, in terms of the corresponding stresses:—

$$\frac{\sigma_v}{(\sigma_y/n)-\sigma_m}=\frac{\sigma_{vo}/\gamma}{\sigma_y}$$

and on dividing through by $\sigma_{vo}\sigma_m/\gamma$ and rearranging, the required mean stress is

$$\sigma_m=\frac{\sigma_y}{n}\left(\frac{1}{\gamma\dfrac{\sigma_v}{\sigma_m}\dfrac{\sigma_y}{\sigma_{vo}}+1}\right) \quad . \quad . \quad . \quad (3)$$

then if

$\sigma_y/n=\phi$=the assigned maximum mean stress.
$\sigma_v/\sigma_m=\alpha$=the stressing ratio or loading ratio.
$\sigma_y/\sigma_{vo}=\beta$=the base diagram stress ratio for uniform diameter polished specimens,

the required modified formula for the permissible mean stress is then:—

$$\sigma_m=\frac{\phi}{\alpha\beta\gamma+1} \quad . \quad . \quad . \quad . \quad (4)$$

The ratio β measures an important characteristic of the material, as prepared for test purposes, and values of it should be obtained and tabulated for all of the principal ferrous materials used in machine design. The value of β is usually greater than unity and therefore the term ϕ, i.e. σ_y/n, representing the maximum permitted value of the mean stress, is generally greater than the sum of any associated values of the mean stress σ_m and the variable component σ_v. According to results quoted by Cazaud[3] for two 23 per cent Ni steels, the ratio β is <1, namely 0·77.

Example 1.—A short uniform diameter connecting-rod is required to carry direct axial tensile loads varying continuously from 25 tons to 5 tons. Tests of the steel in the physical condition for service gave the results : yield strength 21 tons per square inch and an endurance limit under alternating stress (direct load tests) of 16·5 tons per square inch. The correction factor for size and surface conditions, $\gamma=1\cdot1$. What should be the diameter of the middle length of the bar, assuming the factor of safety is three ?

Solution.—The assigned mean stress, $\phi=21/3=7$ tons per square inch.:—

The stressing ratio, or loading ratio:—

$$\alpha=\frac{P_1-P_2}{P_1+P_2}=\frac{25-5}{25+5}=0\cdot67.$$

The base diagram stress ratio $\beta=21/16\cdot5=1\cdot27$.

Then the permissible mean stress is

$$\sigma_m=\frac{\phi}{\alpha\beta\gamma+1}=\frac{7}{(0\cdot67\times1\cdot27\times1\cdot1)+1}$$
$$=3\cdot62 \text{ tons per square inch.}$$

$$\frac{\sigma_v}{\sigma_m}=\alpha,$$

therefore

$$\sigma_v=\alpha\sigma_m=0\cdot67\times3\cdot62$$
$$=2\cdot42 \text{ tons per square inch.}$$

The permissible maximum stress at the maximum load is then $\sigma_m+\sigma_v=6\cdot04$ tons per square inch, and at the maximum load the strength equation is

$$6\cdot04\times\frac{\pi}{4}d^2=25,$$

and

$$d=2\cdot30\text{in.}$$

Therefore the middle short length of the connecting-rod should be $2\frac{5}{16}$in diameter. For a factor of safety $n=1\frac{1}{2}$, the required diameter would be $1\frac{5}{8}$in.

This calculation is not a sufficient answer to the design requirement, because the uniform cross sections of such a machine part would be accompanied by changes of form and cross section at the ends. These changes give rise to local stresses of higher value, and it is usually more important to design these ends for resistance to fatigue failure, and afterwards check for the magnitude of the stresses at other critical sections. The experienced designer usually knows approximately where high stresses occur, and therefore checking does not take up much time.

The Effect of the Form and Quality of the Surface

Over a wide range of machine design for static stress conditions the effects of the surface form and the surface quality do not seriously diminish the durability of a machine part under service conditions. This arises from the fact that the increased stresses incidental to surface form and quality are usually below the yield stress or proof stress of the material, and if the high local stresses, consequent on overload or error in design, reach the yield stress of the material, there is usually sufficient ductility present to permit local yielding without seriously impairing the safety margin of the machine part as a whole. In general, the results of machine design for static stress are successful because observations show that over a wide range of recorded failures of machine parts there are relatively few failures of parts subjected to static stress, and those that occur are sometimes attributed to causes other than defective design, e.g. defective material, excessive overloading, excessive corrosion, &c. But when the machine parts are subjected to cyclic stress, the effects of the form and the quality of the surface require careful consideration in design procedure. *The principal purpose of design is now, not so much to ensure that the strength of the part as a whole is satisfactory, as in static stress design, but rather to ensure that the local or concentrated stresses, produced on comparatively minute areas under service conditions, do not exceed certain assigned safe limits.* This special attention to the provision of safe stresses at or over a small isolated area of a cross section is the principal distinction between design procedure for cyclic stress and the design procedure for static stress. The provision of safe stresses at the isolated points of high local stress usually ensures that the strength of the machine part as a whole would be satisfactory.

The characteristic effect of surface form and quality is shown in Fig. 7.

Three elastic bars of defined surface quality and form are subjected to cyclic loading $P_1 \rightleftharpoons P_2$. The cross-sectional areas of (a), (b) and the notched section of (c) are equal, and the mean stresses and average values of the stresses at the limits of loading are constant over (a), (b) and (c).

In (a) the stresses referred to the relatively large unit areas of practical design are uniform over the whole cross section. The stresses referred to very minute areas are not uniform, but the aggregate effect over larger unit areas may be regarded to be uniform.

In (b) the surface quality affects the magnitude of the stress near the surface, this being $k'\sigma_v$ above σ_m instead of σ_v, as in (a), and the value of k' increases slightly above unity as the surface quality changes from the perfect smoothness of perfect material to the rough machined or rough filed surface of commercial quality materials. Early important enquiries into the effect of surface quality were made by Eden, Rose and Cunningham[4] and Thomas.[5]

In (c) the abrupt change of surface form, produced by the groove, induces a greater variation of the stress over the cross section, and at the surface, the increase of stress above the mean stress is now much higher, being $k\sigma_v$, instead of σ_v as in (a), and the value of the coefficient k depends mainly on the form of the groove, the adjacent form of the part, the rate of stress change, the notch sensitivity of the material, appropriate to the notch form, and the quality of the surface finish at the base of the groove, i.e. k depends on the value of the effective stress concentration factor K_e. This factor is related to the theoretical stress concentration factor K_t and the notch sensitivity N which is expressed in a form proposed by Thum and Buchmann[19] and Peterson,[2] viz.:—

$$N=\frac{K_e-1}{K_t-1} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where :

$$K_e=\frac{\text{The endurance limit without stress concentration}}{\text{The endurance limit with stress concentration}}$$

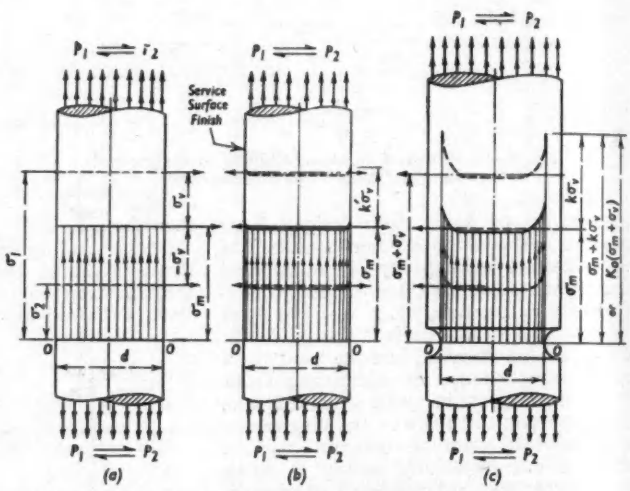


Fig. 7—Diagrams to illustrate the effect of the form and the quality of the surface

$$K_t = \frac{\text{Theoretical maximum stress with stress concentration}}{\text{Theoretical maximum stress without stress concentration}}$$

In the case of K_t, it is assumed that the material is perfectly elastic ; and under such an ideal condition, the notch sensitivity $N=1$. When the metal is unaffected by the presence of a notch, as in the case of some grey cast irons, $N=0$.

The factor K_e is related to the breakdown limit of internal stresses, and therefore for safe stresses, it is more reasonable to think in terms of an *operative* stress concentration factor K_o. This factor may have almost any value between K_t and K_e depending on the magnitude of the stresses on the notched section. For design purposes K_o is the more important factor.

There is a large amount of information on the effects of stress concentration for a wide range of machine part surface forms, and numerous convenient references and summaries bearing on this matter may be found in Cazaud's book.[3] Some values of the effective stress concentration factor have been obtained by Lehr and Mailander[6] for shouldered steel specimens subjected to rotating bending, and by Herold[7] for shouldered specimens subjected to cyclic torsion. In the latter, notch sensitivity values are also given. Additional references to relevant work are included in the Bibliography.

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(To be continued)

TRAVELLING INSTRUMENT EXHIBITION.—To overcome the problems of high costs of participating in overseas trade fairs, the Scientific Instrument Manufacturers' Association of Great Britain has developed for its members a self-contained and easily transportable display stand. The display stand consists basically of a central panel with a pedestal in front of it, on which a single instrument may be shown, and two side panels on which photographs of other products may be mounted. The pedestal has a space for sales and technical literature, and a slot through which inquiries may be dropped. The stand can be easily collapsed and folded flat for transport by road, rail, sea or air, and may be erected anywhere without skilled labour. One unit can stand alone or any number may be built up into a variety of patterns and shapes, from a rectangle with a temporary office in the centre, to a straight line which can be erected in the corridor of a public building. The association is sending an exhibition on tour to various European countries to show its members' products not only at established fairs and conventions, but wherever there is sufficient interest.

Research and Development Work on Semi-Conductors

Research and development work on semi-conductors is being carried out in a new two-storey extension to the G.E.C. research laboratories at Wembley. The company's research effort is now greater in this particular field than in any other branch of electrical engineering outside defence. It involves fundamental work in the physics of solids ; the preparation of semi-conductor materials with properties suitable for practical application ; the development and initial manufacture of new devices from existing semi-conductors ; and work on the evaluation of semi-conductor devices and their application in electronic circuits. An outline of this work is given here.

LAST week we visited the research laboratories of The General Electric Company, Ltd., at Wembley, to see something of the company's research and development work on semi-conductors. These activities are now concentrated mainly in a new two-storey wing which forms an extension to the main block of buildings at Wembley.

In an introductory talk before the tour of the new wing Mr. O. W. Humphreys, director of the company's research laboratories, emphasised the importance of semi-conductors as devices which were likely to have a revolutionary effect on electronic engineering. He pointed out that, excluding research on defence projects, the largest single item in the company's research effort was that devoted to semi-conductors and their application.

To appreciate the importance of these developments and the speed with which they are progressing we should perhaps begin by noting, briefly, some of the main phases in the history of semi-conductors.

The practical uses of these materials in the radio frequency ranges date back to the crystal detector which was extensively used in the earliest days of radio but almost forgotten after the rapid development of the thermionic valve. A revival of interest in semi-conductor devices came in 1940 when the silicon crystal diode was used as a mixer or frequency changer in almost all ultra-high-frequency radar equipment. A later development was that of the germanium point contact diode which is now used in communications and industrial control equipment.

Great impetus was given to the study of semi-conductors by the discovery of the transistor in 1948, when Bardeen and Brattain of the Bell Telephone Laboratories found that a triode amplifier could be made by arranging two-point contacts close together on a small slab of germanium. While the full implications of this discovery have yet to be realised, its great importance was immediately apparent. About two years later another milestone was reached with the discovery of the p-n junction rectifier. Essentially this consists of a block of germanium, one part of which has an excess of p-type impurities (atoms that will accept electrons) and the other an excess of n-type impurities (atoms that will donate electrons). The potential barrier set up at the junction allows current to flow more easily in one direction than the other, giving a rectifying effect. Yet another device, the junction triode, was developed shortly afterwards. This can take many forms but is basically a sandwich in which a thin n-type layer separates two p-type regions, or vice versa. Such p-n-p or n-p-n triodes are capable of very efficient amplification.

The advantages of the new devices have been enumerated many times : long life, ruggedness, small size, low power consumption, &c. Further, it was soon apparent that they should be regarded as far more than mere replacements for thermionic valves. As the fundamental properties of this class of materials were investigated, it became clear that they would fulfil other purposes besides the rectification and amplification of electric current. For example, both the point contact diode and the junction diode can be designed so that the characteristics are sensitive to light, and the efficiency can be higher than that of any existing photosensitive device. Discoveries like these indicate that other possibilities of equal significance will follow from concentrated research embracing the fundamentals of semi-conductors, the preparation of these materials, the development of new devices employing them, and the investigation of their hitherto unexplored applications.

In view of these possibilities it was clear that semi-conductors would have a profound effect on many of the activities of The General Electric Company : accordingly, in 1952, the company began to extend its research laboratories to provide space in which this expanding research could be accommodated. A large two-storey wing now supplements the space previously available for semi-conductor research and development. It includes departments that are concerned with fundamental work on the physics of solids and the preparation of new semi-conducting materials ; the preparation of semi-conductor materials with the properties required for use in the development of devices ; the development and initial manufacture of new devices from existing semi-conductors, and work on device evaluation and electronic circuit applications.

Future plans provide for still further expansion in this field of research, and we learn that the company decided only three weeks ago to initiate further laboratory extensions at a cost of about £50,000.

BASIC RESEARCH

Research to find new semi-conducting materials is important for two reasons. First, known semi-conductors such as germanium and silicon have physical properties (such as energy gap and charge carrier mobilities) which are not ideally balanced for use in some devices. It is possible to envisage materials with more desirable properties—materials which would be neither so rare nor difficult to prepare as the semi-conductors used at present. The laboratories are making and investigating the properties of such materials, including a new group of compounds with a crystal structure closely related to that of silicon and germanium. Known as chalcopyrite-type materials, they have already been shown to possess interesting semi-conducting properties. For example, copper indium selenide (Cu In Se_2) has shown point contact rectification with peak inverse voltages of about 400V.

The second purpose of research into new materials is to give greater insight into the physical properties of semi-conductors. This field is relatively undeveloped but already many unusual effects, thermal, optical and magnetic, as well as electrical, have been discovered. An investigation into the thermo-electric effects in semi-conductors forms part of a programme to elucidate some of these unusual properties. Thermo-electric effects are well-known in metals, as a result of Peltier's discovery, 120 years ago, that a junction of two dissimilar metals is cooled or heated when an electric current is passed across it. The magnitude of the effect is, however, very small if conventional metals are used. Some semi-conductors show a far more favourable combination of properties and it was possible to choose, out of the large number recently prepared in the laboratories, the particular material which would be expected on theoretical grounds to give the best performance. The junction of the metal bismuth and the new semi-conductor bismuth telluride can be used to produce a temperature difference of 26 deg. Cent., and work on other materials is proceeding with a view to obtaining even greater effects.

Research into new semi-conductors requires highly specialised apparatus. Usually the materials investigated must not only be of

Fig. 1—Using a micro-manipulator to examine the electrical characteristics of ionically bombarded silicon slices

Fig. 2—Removing a single crystal ingot of germanium grown by rotating a small crystal seed in molten germanium

particular purity but also, in order to study their properties adequately, in a perfect crystalline form. Minute traces of impurities or tiny defects in the crystal can radically alter the properties. In addition, almost all the starting materials of interest, such as arsenic, antimony, selenium and tellurium, are poisonous, although the final product is usually inert and harmless. Reactions have therefore to be carried out in special sealed containers or in the high-velocity fume cupboards with which the laboratory has been equipped.

Fundamental studies have shown that a knowledge of the bulk properties is not sufficient for solving application problems. Every specimen is necessarily limited by a surface which, in an actual device, may be exposed to atmosphere or joined to another surface. The phenomena occurring at the surface of a semi-conductor are in fact radically different from those in the bulk material. Even with silicon and germanium the present understanding of the surface phenomena is incomplete, and this is even truer of the new semi-conductors.

The effect of various surface treatments on the electrical properties of these materials is being studied in the laboratories (Fig. 1). For example, the bombardment of a silicon surface with ions of various gases accelerated by an applied potential of 30kV produces a drastic change in the electrical properties. A comparison between the current voltage characteristics of the treated and untreated materials shows that the ion bombardment has induced a permanent improvement in the rectifying effect.

Semi-Conductor Materials

The problems involved in the preparation of suitable semi-conductor materials can perhaps best be illustrated by reference to germanium. The material used by British manufacturers of crystal valves is obtained from the dust and soot which collects in the flues of gasworks, particularly where coals from Northumberland and Durham are used. The G.E.C. research laboratories carried out an extensive search for an indigenous source of germanium several years ago, and as a result a substantial annual tonnage of germanium-bearing flue dust is now available. The semi-conductor, once so rare as to be considered a chemical curiosity, is usually present as 0·5 to 1·0 per cent by weight in the better flue dusts and can now be obtained in quantities of the order of hundredweights.

After its extraction from the flue dust germanium is given elaborate chemical purification and is supplied to the laboratories as germanium dioxide, which is then reduced by high temperature treatment with hydrogen. The metal thus obtained is fused and cast into an ingot, which has about one part of impurity to every 10,000,000 parts of germanium. Although very pure by chemical standards, this is still almost a hundred times as impure as required for semi-conductor devices.

Further purification is required and it is effected by a directional freezing technique known as "zone refining." Only a small region of the ingot is melted at any one time, but the heat source is moved so that the molten zone also moves and slowly traverses the length of the bar. During the process impurities, when at the junction of liquid and solid, are concentrating

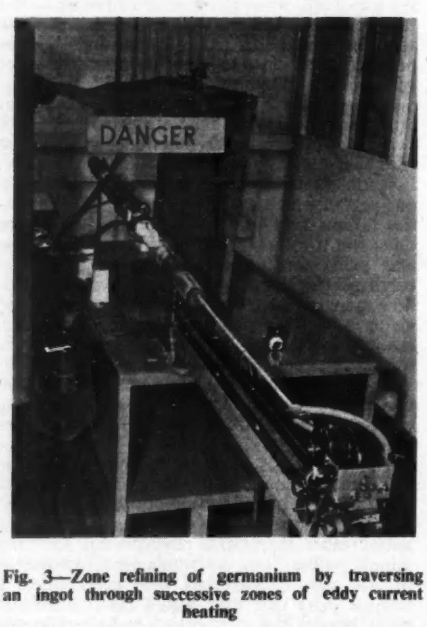

Fig. 3—Zone refining of germanium by traversing an ingot through successive zones of eddy current heating

preferentially in the liquid zone. By repeatedly traversing the bar, therefore, the impurities are ultimately swept to one end of the ingot, which is then sawn off. The process of zone refining is carried out by eddy current heating in an apparatus which is illustrated in Fig. 3. The output side of the h.f. generator can be seen to the left of the coils which provide the heating zones. The germanium ingot, placed in a graphite crucible, is traversed along the quartz tube by a motor-driven carriage.

Having obtained germanium of suitable purity, it then becomes necessary to prepare it in the form of a single crystal so as to give the required electrical properties. The metal is again melted, this time in a crucible, and a minute controlled amount of the element which determines the electrical properties is added. A small "seed" of monocrystalline germanium is dipped into the molten mixture and there it is rotated at about 60 r.p.m.. With very precise temperature control (for example, 935 deg. Cent ±0·5 per cent) the germanium begins to deposit in solid form on the "seed." By withdrawing the growing crystal at a predetermined rate the entire contents of the crucible can be made to solidify in the form of a monocrystalline ingot (Fig. 2).

After being tested to ensure that it has the required crystalline and electrical properties, the germanium ingot is then sawn and ground into the small plates used in the manufacture of crystal valves. The production of silicon for use in semi-conductor devices can also be achieved by this single crystal method.

Semi-Conductor Devices

Another aspect of the company's work on semi-conductors is that of using the available materials to develop new circuit elements that will meet the needs of industry. Mention has already been made of the early work on the design and production of point contact silicon crystal diodes for high-frequency mixer work. Now, after a period in which the main emphasis has been on germanium devices, attention is again being focused on the use of silicon. Preliminary studies have indicated that silicon p-n junction diodes have several useful characteristics, including the ability to operate at considerably higher ambient temperatures than their germanium counterparts, very low inverse currents and a large rectification ratio between forward and reverse currents.

To prepare silicon p-n junctions, donor and acceptor electrodes are attached to a homogeneous silicon crystal of either type by heating the crystal and then bringing it into contact with metals to which it will alloy. A junction with p-type silicon, for instance, is made with a "donor" metal or an alloy containing a "donor" element such as antimony, phosphorus or arsenic. The junction is grown by deposition from the molten alloy when cooled and is situated between the unmelted silicon and the metal solid solution. An ohmic or base contact can be formed in the same way, except that, on p-type

silicon, for example, an "acceptor" element such as aluminium or indium is used. By careful control of the heating and cooling cycle, and the selection of suitable metals and alloys, both the junction and the base contact can be formed simultaneously.

In one of the techniques being used a gold-antimony alloy wire forms a p-n junction on p-type silicon and an aluminium wire provides the base contact. With n-type silicon these roles would be reversed, but no changes would be required in the manufacturing technique.

Germanium p-n Junction Diodes.—In the manufacture of germanium p-n junction diodes, on the other hand, the junction is formed by fusing a bead of indium metal on to the carefully ground and etched surface of a wafer of single crystal n-type germanium. The fusion is carried out in an electric furnace. As the temperature rises, a liquid indium-germanium alloy is formed, the percentage of germanium increasing with temperature. On controlled cooling to room temperature, the germanium recrystallises, together with enough indium to form a low-resistivity p-type layer as a continuation of the original crystal structure. There is thus an abrupt change in conductivity type at the junction between the original n-type and the recrystallised p-type materials. The resulting potential barrier leads to the well-known rectifier characteristic.

One of the rectifiers now being developed has a fairly massive copper base to remove heat dissipated in the device. When the p-n junction has been made, an enclosing copper cap is hermetically sealed to this base by a cold pressure welding technique. To avoid contamination this operation is carried out in an enclosure

Fig. 4—Experimental germanium p-n junction rectifier developed for use with vehicle electrical systems

which provides an atmosphere of dry nitrogen The success of this sealing method is such that these units have withstood long periods of storage under severe conditions of high temperature and humidity, without change of characteristics.

Medium power germanium p-n junction diodes have been designed for use in bi-phase (full wave) circuits to provide 10A rectified current at 6V or 12V. A typical static characteristic for the rectifier shows a current of +10A at 0·55V and −2mA at −50V. Because of the low forward resistance an overall efficiency of 95 per cent or more is readily achievable in a.c./d.c. conversion. As the heat dissipation is low, small cooling fins of simple design can be used (Fig. 4).

Germanium Power Rectifiers.—A complete rectifier can be designed and built to deliver large powers (for example, of the order of several hundred kilowatts) by connecting numbers of the present smaller units in series and in parallel. But this technique introduces difficulties in matching the rectifiers to ensure that they will share the load equally. The company is, therefore, proceeding with the development of a germanium rectifier with a much larger area and an efficient cooling system to dissipate the heat losses.

Germanium Junction Triodes.—Just as the point contact diode has a counterpart in the p-n junction diode, the point contact triode, too, has its junction counterparts, the p-n-p or n-p-n triodes. The three regions making the "sandwich" are not three separate crystals joined together but a single continuous crystal lattice in which the conductivity type is changed abruptly by alternating the nature of the impurity atoms in passing from one region to the next. Ohmic contacts, termed emitter, base and collector, respectively, are joined to the three regions. The action of the device is such that the collector current is dependent on the emitter current and, since the impedance of the collector is much higher than that of the emitter, amplification of a signal is possible.

One method of making a junction triode is to grow a germanium crystal and to vary the nature of the impurity atoms during growth to produce three regions with the correct spacing. Such a crystal is then sawn into small pieces for fabricating triodes, the junctions being known as "grown junctions." Alternatively, a method similar to that for germanium diodes can be used. A pellet of a suitable impurity metal is placed on a semi-conductor crystal of a certain conductivity type and the temperature raised. The pellet melts and dissolves some of the germanium to form molten alloy. By reducing the temperature slowly the dissolved material is redeposited on the crystal, but enough impurity atoms remain in solid solution to alter the conductivity type. If this process is carried out on the opposite faces of a thin slice of germanium, two thin layers of opposite conductivity type to the bulk of the crystal will have been formed, giving a triode configuration. Junctions obtained in this way are called "alloy junctions." This alloy technique is being used in the manufacture of triodes in the G.E.C. laboratories, and the complete assembly is mounted in a hermetically sealed container. These experimental units can be made with current gains up to 100 and collector voltage ratings up to 25V, and will operate at frequencies up to a few hundred kc/s.

High-frequency Germanium Junction Triodes.—The performance of junction transistors has an upper frequency limit since a finite time is taken for charge carriers to migrate between emitter and collector. A higher frequency response would therefore be expected as a result of a reduction in the base layer thickness and it is found that a reasonable amplifier gain at 10Mc/s is in fact obtained if this thickness is reduced to 0·0005in. The required reduction is achieved by drilling a cavity in a germanium wafer 0·006in thick. A successful method of machining such a cavity, using a jet of electrolyte to etch the germanium, has now been developed in the laboratories to a stage where the depth of cavity is controllable to within 0·0001in. The set-up is illustrated in Fig. 5; a jet of potassium hydroxide is directed through a negatively charged nickel tube on to a positively charged germanium wafer. The high frequency p-n-p germanium triode using such a drilled wafer has essentially the same construction as the lower frequency device. While the junctions are also prepared by the alloy method, it is more important in this case to prevent the junction from penetrating to any appreciable depth into the n-type germanium. An indium-germanium alloy, therefore, replaces the pure indium bead used previously and the period and temperature of firing have to be rigorously controlled.

High-Frequency Germanium Point Contact Triodes.—The performance of point contact germanium triodes also falls off as frequency is raised because of the effect of the emitter-collector spacing. Although this is small by ordinary standards (in the "GET1," for instance, it is 0·003in), smaller point spacings still are required to improve the high frequency response.

A point contact germanium triode, recently designed in the laboratories, will oscillate at frequencies as high as 100 Mc/s. The problem of the close spacing required has been solved by using special assembly methods which allow distances as small as 0·0005in to be achieved. For amplifier use, point spacings less than 0·00075in have not so far proved useful because of the increasing effect of surface properties as spacing is reduced. This sets 10 Mc/s as a reasonable manufacturing limit for amplifiers incorporating these devices.

Applications of Semi-Conductor Devices

In the early exploratory stages of development attention has been concentrated on devices based on the electrical characteristics of semi-

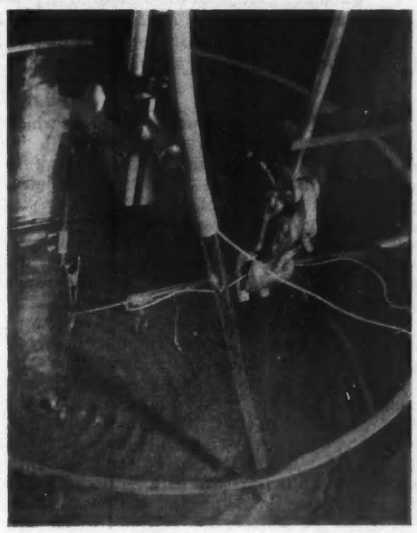

Fig. 5—Electrolytic etching of a cavity in germanium. A jet of potassium hydroxide from a negatively charged nickel tube impinges on to a positively charged germanium wafer

conducting materials. However, it is likely that exploitation of their electromagnetic, photo-electric and thermoelectric properties will lead to new devices, the full impact of which cannot yet be foreseen. The main uses of the present semi-conductor devices are in electronic equipments where small size, light weight, long life, ruggedness, reliability and low power consumption are important considerations. Much work is therefore being done in the design of suitable circuits for use with crystal valves and on the determination of the principles of operation.

Crystal valves are at present limited in their range of application by their maximum frequency of operation and their power output, those readily available being usable only up to frequencies of about 500kc/s with output powers of a fraction of a watt. These limits are, however, being rapidly extended by improvements in design and the development of new types. Experimental valves have already been established which are capable of operating up to 10 or 20 Mc/s as amplifiers and up to 100 Mc/s as oscillators, while others working in the audio frequency range are capable of giving several watts output.

The most immediate and most significant of applications for crystal valves are likely to fall in the telecommunications field. For example, crystal valves are likely in future to be found at many points in telephone systems; in exchanges, repeaters and subscribers' equipment. Many of the circuit problems involved are common also to computers and calculating machines.

In domestic radio and television receivers the earliest use of crystal valves is likely to be in "personal" or small portable radio receivers, which will give performances equal to present valve receivers but will require only one-tenth the power.

Because of the wide variety of frequencies, waveforms and powers to be handled, the design of television receivers has required a large range of thermionic valve types. This range will probably be even greater for crystal valves, at their present stage of development, making any complete change of design to crystal valve operation unlikely for some time. Germanium diodes are already fulfilling a number of functions in present television receivers and other semi-conductor devices may be introduced gradually as they are developed for other uses.

Carmarthen Bay Power Station

Carmarthen Bay power station was officially opened by Sir Henry Self, deputy chairman (administration) of the British Electricity Authority, on Friday, August 27th. Of the two existing 52·5MW turbo-alternators, the first was commissioned on June 28, 1953, and the second in September, 1953. Four 60MW hydrogen-cooled sets are due to be installed by 1957, making the total capacity of the station 345MW. Steam is generated at 940 lb per square inch and 925 deg. Fah. in 240 k lb per hour, p.f. fired boilers, of which fifteen will ultimately be installed.

CARMARTHEN Bay power station, which was officially opened on August 27th by Sir Henry Self, deputy chairman (administration) of the British Electricity Authority, is designed for an ultimate capacity of 345MW, and occupies a site of about 214 acres on the Burry estuary. Although this site had natural advantages, including ample cooling water, access to the water was made difficult by the 30ft tidal range which characterises the Burry estuary.

Various aspects of the civil engineering work are of special interest and here we refer briefly to some of the major considerations. For the foundations of the station buildings, trial borings showed that, under the superficial slag deposits there was a depth of about 20ft of fine brown sand, overlaying 40ft of grey silty sand, interlaced with clay seams. A thick seam of sandstone was found at a depth of 65ft. Because the standing water level on the site was about 12ft below the surface, a dewatering system was required for work on the boiler-house and turbine house excavations, which were, respectively, 3ft above and 12ft below O.D.

To provide a suitable site for the circulating water pump house, a portion of the foreshore had to be reclaimed. Accordingly, a protective embankment, about 30ft high by 700ft long, was built to enclose the site on the seaward side and form a breakwater enclosing a land-locked area for the pump chamber excavations.

Because of the tidal range of 30ft, it was necessary to build a very deep pump house, so that the pump suction inlets would be drowned at all tide levels. The excavations were carried out inside a sheet steel pile cofferdam. An unusual constructional method was used: a reinforced concrete diaphragm was cast 5ft below ground level, circular openings being formed in the diaphragm so that excavation could proceed underneath. A second diaphragm, also with circular openings, was formed on the floor of the excavation and underneath it further excavation was carried out. This process was repeated, in succession, until six diaphragms had been completed; the last diaphragm formed the base of the pump house.

The main buildings are supported on 5500 r.c. piles, from 40ft to 55ft long, cast on site; the construction is fabricated steel framing clad with brick. Asbestos decking is used for the roofing. As illustrated in Fig. 1, the main building is arranged with a 740ft by 96ft turbine house, at the side of which there are three separate boiler-houses. In each boiler-house there are five boilers, with space for a sixth, arranged on the two sides of a common firing aisle, which is at right angles to the main axis of the station.

Before describing the boiler-house plant, reference should be made to the coal handling plant, which is of special interest because it avoids the use of gantries which would have marred the architectural appearance of the building. Coal supplies are rail borne, and the 10 miles of sidings to the north of the station building, within the station boundary, can accommodate 600 wagons awaiting discharge and 300 empty wagons awaiting removal.

Each of the three boiler-houses is supplied independently by a pair of "Rota Side" wagon tipplers. Coal from each tippler is discharged into a receiving hopper, and is fed by duplicate electric vibrating feeders on to a 24in wide belt conveyor, which runs in a tunnel under the railway sidings to the boiler-house. The belt conveyor is provided with a magnetic head pulley, and a suspended magnet, for removal of tramp iron. Each belt conveyor discharges into one or other of two encircling gravity bucket conveyors installed in the chimney base, to raise the coal to a sufficient height to enable it to pass through crushing and screening plant before proceeding to the boiler-house bunkers. Each of the top runs of these two conveyors is provided with a dumping point, and the coal can be discharged into chutes for passing through crushers, and then over "Niagara" screens, where non-metallic rubbish can be removed. After passing through the screens, the coal passes down to rotary fillers and thence to the main gravity bucket conveyors, in which it is raised and carried forward over the overhead bunkers in the boiler-house. Because excavations were very limited under the chimney base, there is no arrangement for interchange of feed between the two sets of conveyors.

Along the horizontal run of the gravity bucket conveyors passing over the bunkers dumpers are arranged, four per bunker pocket, to enable the coal to be discharged into the pocket taking full advantage of its capacity. From the bunker outlets, the fuel is discharged through water-collecting gates down chutes into the mills. Provision is made at firing floor level for the installation of test weighers which can be put into place or taken away as desired, and the coal chutes are suitably interrupted to permit this arrangement.

The gravity bucket conveyors are arranged for internal lubrication by "Tecalemit" automatic grease lubricators. These machines can be put into operation or taken out, as desired, and normally they will be in operation for about an hour in each shift. When in operation, the lubricators force grease into each nipple on the chain joints, so ensuring that the moving surfaces associated with an articulated chain are well lubricated.

Each of the duplicate wagon discharging and conveying systems feeding each boiler-house can handle 75 tons of coal per hour, so that both systems working together provide a capacity of 150 tons per hour.

The coal stock area can accommodate 140,000 tons and lies to the north-east of the station building, between the marshalling sidings and the British Railways line between Llanelly and Burry Port. Coal for stocking is discharged from wagons by tippler on to a stocking-out conveyor. Reclamation is effected, as required, by bulldozers and carry-alls, which transfer the coal via a travelling telpher into wagons for transport to the boiler-house tipplers.

Boiler Plant

Each boiler (Fig. 2) has an evaporative capacity (m.c.r.) of 240,000 lb per hour, the steam conditions being 940 lb per square inch and 925 deg. Fah. and the feed temperature at economiser inlet being 365 deg. Fah. The boilers are Babcock and Wilcox high-head units, having straight steam generating tubes expanded into forged headers. The furnaces are water cooled, with Bailey blocks, and are designed for burning semi-bituminous coal, with a minimum volatile content of 13 per cent and a maximum ash content of 15 per cent, in pulverised form. Pulverising is carried out by three "E44" mills per boiler. There are nine vertical inter-tube burners per boiler, located in an arch near the top of the furnace, firing downwards.

For lighting up each boiler is fitted with two retractable pressure-atomising oil burners. They automatically enter through furnace ports when oil pressure is applied, and are ignited by a spark from a high-tension transformer, being extinguished and retracted when the oil pressure is turned off.

The superheaters are of multi-loop form, with surface type attemperators between primary and secondary stages, for control of final steam temperature. Gas by-passing arrangements are also provided. The economiser is also of multi-loop form, disposed in two banks, arranged in parallel on the water side. With feed temperature of 365 deg. Fah. the estimated temperature at the leaving end of the economiser is 502 deg. Fah. Two Howden-Ljungstrom rotary air heaters are provided, per boiler, the estimated temperature of the combustion air being 533 deg. Fah. at m.c.r.

Each boiler has two induced draught fans with an output of 62,000 cubic feet per minute at m.c.r. and two forced draught fans of 39,700 cubic feet per minute, both i.d. and f.d. fans being driven by variable-speed motors. In addition, there are two primary air fans with a maximum output of 26,000 cubic feet per minute and three

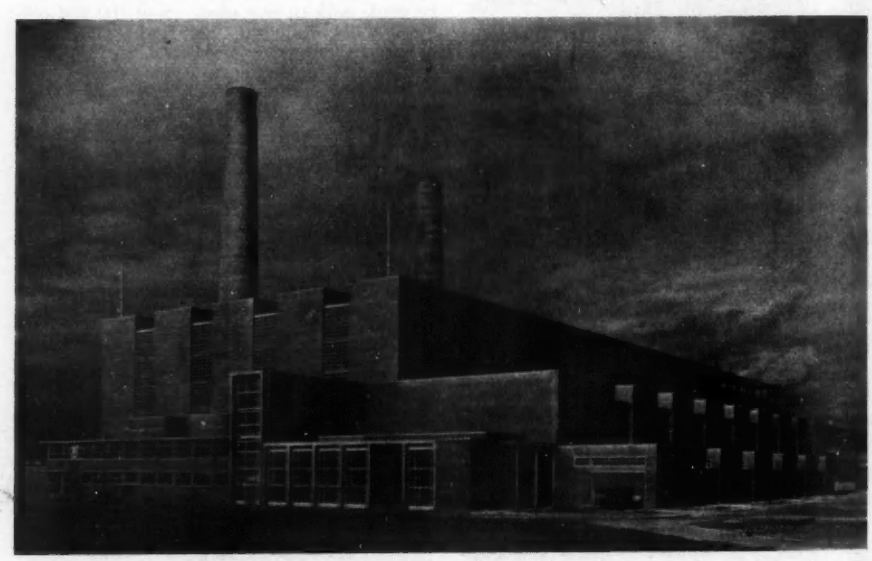

Fig. 1—Carmarthen Bay power station from the south-west. This photograph shows the elevation of the boiler-house, the turbine room and, on the right, the transformer cells. The south-west corner of the building is occupied by a workshop

sealing air fans. Grit arresters and electrostatic precipitators are fitted to each boiler.

There are twenty-two soot blowers to each boiler unit, of which eighteen, located in the furnace and superheater, are of the pilot valve, retractable single-nozzle design, the remaining four, located in the air heater, being fixed-element blowers. Automatic sequence control, on the Babcock-Lockheed hydraulically operated system, is arranged to give fully automatic control of the full range, or pre-selected suppression of any individual blowers from the cycle, or individual operation of any selected blower. If, during the general operation, any blower head fails to complete its operation within a given time, blowing ceases and an alarm sounds. Manual operation can also be carried out, if desired.

Comprehensive instrumentation and automatic combustion control equipment is provided, each boiler having its own control panel, with a master boiler control board in a separate glass-partitioned room at the head of the firing aisle.

Each boiler in the first boiler-house is equipped with a dry ash hopper. From this hopper the ash is discharged at intervals, via sluiceways to the ash sump (together with dust collected from the mechanical arresters, electrostatic precipitators and flues) and is pumped to ash ponds to the east of the station, beyond the switch-house.

For the second and third boiler-houses similar arrangements will be provided except that the ash hoppers will be water-filled. Interconnections will be provided to enable any ash sump to deal with adjacent boiler-houses, if required. The high-pressure sluicing water is supplied by four sluice pumps installed in the circulating water pump house.

Turbo-Alternators

As already indicated, the first two turbo-alternators are 52·5MW sets and are in commission. The first of the 60MW sets is now being erected in the power station, and succeeding sets are being manufactured. All are Metropolitan-Vickers machines. In the first two turbo-alternators the turbines are three-cylinder machines, designed for initial steam conditions of 900 lb per square inch gauge, 900 deg. Fah., the speed being 3000 r.p.m. Each 52·5MW turbine consists of eleven impulse stages in the high-pressure cylinder, fourteen stages in the intermediate-pressure cylinder, and five stages in each half of the double-flow low-pressure cylinder. Each 60MW turbine consists of eleven impulse stages in the high-pressure cylinder, thirteen stages in the intermediate-pressure cylinder and five stages in each half of the double-flow low-pressure cylinder. The blading material throughout is of stainless steel.

Five stages of feed heating are incorporated in the heat cycle of each turbine, the final condensate temperature at m.c.r. being 365 deg. Fah. for the 52·5MW machines and 380 deg. Fah. for the 60MW machines.

The designed steam and heat consumption figures are tabulated herewith.

Designed Steam and Heat Consumption Figures

Nominal Rating, MW	Output, MW	Steam consumption, lb/kWh	Heat consumption, B.Th.U./kWh
52·5MW	52·5	8·433	9390
	42·0	8·472	9567·6
	31·5	8·604	9869·5
60MW	60	8·429	9250
	48	8·44	9405·7
	36	8·516	9671

In the 52·5MW turbines each low-pressure cylinder is connected to twin condensers, having a total condenser cooling surface of 52,500 square feet, and each condenser is capable of dealing with 330,000 lb. of exhaust steam per hour at a vacuum of 29in Hg. (barometer 30in Hg.) with a cooling water inlet temperature of 58 deg. Fah. For the 60MW machines the condenser cooling surface is 60,000 square feet, handling 377,000 lb steam per hour at a vacuum of 29in Hg., with cooling water inlet temperature 58 deg. Fah.

Each of the 52·5MW turbines is direct coupled to an a.c. generator of 61·765MW capacity (0·8 p.f.) at 11·8kV, three phase, 50 c/s. These machines are of the company's standard design for this size. They are air cooled with closed circuit ventilation, the water-cooled air coolers being mounted below the generators in the foundations. Air is circulated through the machines and over the cooling tubes by separate fans, and the air pressure inside the machines is maintained at slightly above atmospheric. The

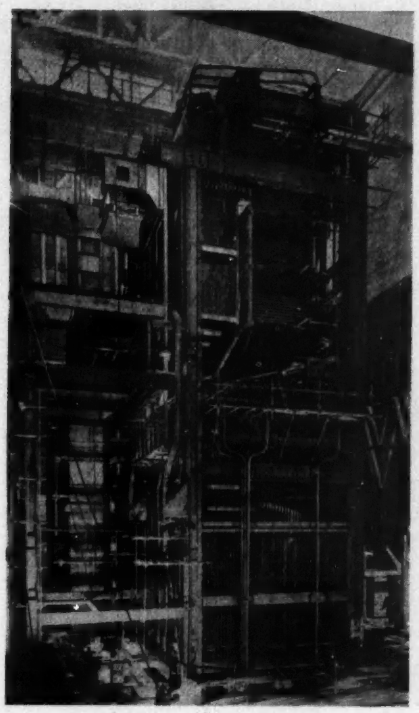

Fig. 2—High-head boiler during erection at Carmarthen Bay power station. The Bailey wall tubes, superheater and economiser can be seen

generator stators are of fabricated construction, with 11·8kV three-phase involute windings. The rotors are made from single steel forgings; no fans are fitted on the rotors, all the air circulation being from the independent fans mentioned above. Excitation is from direct-connected exciters running at 3000 r.p.m., and from pilot exciters overhung from the main exciter.

The generators to be driven by the 60MW turbines will be rated at 75MVA and will be hydrogen cooled.

In the feed-water system three 550,000 lb per hour electric pumps and one steam pump of the same capacity are installed to work with two alternators and five boilers. The pipe work on the suction and discharge sides is so arranged that one of the electric feed pumps acts as a standby to each of the main electric pumps. Moreover, the steam-driven pump can serve as standby to any of the electrically-driven pumps.

Make-up for the feed-water is taken from the town's unfiltered supply and passed through a water softening and evaporating plant. The water softening plant at present installed has a capacity of 40,000 lb per hour, and there is one live steam evaporator of 20,000 lb per hour capacity per set, which feeds into the feed suction line. A conservator tank is installed to collect clean drains and to facilitate boiler emptying without loss of feed-water.

Electrical Equipment

The generated outputs are fed into the Grid transmission system through six main transformers each with a no-load ratio of 11,800/141,600V, the first two being of 63,000kVA capacity and the remaining four 72,000kVA capacity.

Supplies for station auxiliaries are obtained from two station transformers of 10,000kVA capacity with a no-load ratio of 132kV/3457V, and from six unit transformers of 6000kVA capacity with a no-load ratio of 11,800/3457V. They are installed in cells along the south side of the turbine house and are all water-cooled. The generator and station transformers are fitted with on-load tap changing gear.

The unit and station transformers feed the auxiliary network which consists of 3300V, 150MVA and 415V, 25MVA air-insulated air-break switchgear. The unit and station boards are situated in the switchgear room in the tank annexe with boiler boards, &c., situated in switchgear annexes adjacent to the boiler-houses. Air-cooled auxiliary transformers of 250kVA and 500kVA capacity and no-load ratios of 3300/433V are housed with the switchgear. A 150kVA emergency diesel set maintains essential services in the event of a complete shutdown.

Main Switchgear

Main switching is effected at 132kV and the arrangement adopted is unusual for this country

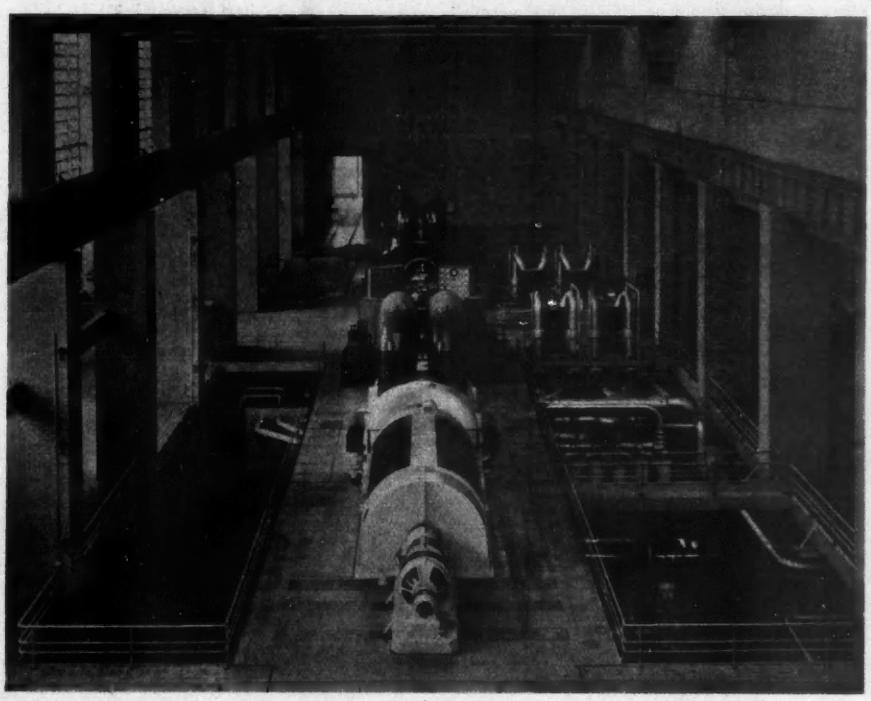

Fig. 3—Turbine house, with two 52·5MW turbo-alternators installed. There is provision for four 60MW sets to be installed at a later date

in that it consists of outdoor air-blast switchgear accommodated in a "hall-type" building, which gives protection from salt spray. This protection has made it possible to reduce certain clearances and has resulted in a considerable saving in floor space.

The switch house lies to the east of the main building and is 320ft long, 90ft wide and 50ft high. It is divided into two main halls, east and west, by a central block which contains the feeder and busbar protective gear, compressed air and CO_2 fire-fighting equipment, low voltage a.c. and d.c. distribution boards, offices and store accommodation and a room for the main busbar section switch. There is a basement of cellular construction under the whole building, for cables and air lines; it has ninety-two compartments and provides a rigid floor.

Fig. 4—Central control room at Carmarthen Bay power station

In each half of the building there is space for ten circuit-breakers with associated isolators and connections for a double busbar layout. In each half the reserve busbar is in the form of a "U" running along the north, south and central block walls and the two halves are coupled together via isolators and through wall bushings. The main busbar occupies the whole length of the middle of the building and has a section switch with through wall bushings in the central block.

Normally, all the busbars, which are 38ft above floor level, are supported by porcelain insulators suspended from the underside of the roof trusses. Access to these busbars for maintenance is by overhead trolley on rails fixed to the underside of the roof trusses and between the busbars. Normally the trolleys are parked over platforms at the ends of the building and entry to them cannot be obtained until the appropriate busbars are earthed.

All busbar and feeder by-pass isolators are mounted vertically above circuit-breaker level, the main and reserve busbar isolators being erected back-to-back with a screened-off passageway between, from which platforms can be lowered for maintenance work on any isolator. The feeder isolators are mounted horizontally on steel structures in accordance with standard outdoor practice. Electrical and Castell interlocks ensure correct operation and safeguard personnel.

Along the north wall of the switch house there is provision for eight feeder and two reactor circuits. The feeders are all overhead lines which connect the station and the rest of the grid system. Two circuits are connected to Tir John with supply points at Llanelly and Trostre; a third circuit will be connected to Ebbw Vale and a fourth to Upper Boat, both with supply points at Hirwaun, Ystradgynlais and Ammanford. A fifth circuit will be connected to Carmarthen and a sixth to Haverfordwest; the remaining two circuits are spare. The overhead line terminal towers are erected near the switch house wall to enable the lines to be connected directly to the switchgear without the use of cables.

Provision is made for six generator, two station transformer and two bus-coupler circuits along the south wall of the switch house. The generator and station transformer circuits are cable-connected to their respective transformers by single-core 132kV oil-filled cables laid direct in the ground and terminating in end boxes on the transformers and cable sealing ends at the switch house. The three sealing ends for each circuit are housed in a separate compartment; these compartments are built along and outside the south wall. Single-phase voltage transformers with a ratio of 76,200/63·5V are also installed in these compartments.

Paper and oil-insulated condenser bushings are used to carry through walls 132,000V interconnections between overhead lines and cables and their respective switch units and for interconnecting the busbar sections. The bushings are fitted with porcelain weather shields at both ends and accommodate all the protective current transformers.

CO_2 fire protection equipment is fitted only in the cable sealing end bays, where most of the oil-filled equipment is housed.

The air blast circuit breakers are Ferguson-Pailin equipments with two series interruptor heads per phase with a rating of 132kV, 600A, and a rupturing capacity of 2500MVA. The normal operating air pressure is 300 lb per square inch, and four three-stage compressors operating in two banks supply air at an initial pressure of 600 lb per square inch. Each breaker is 16ft 6in high, 7ft centre to centre of phases, and 27ft centre to centre of adjacent units; wire mesh screens separate the units.

The main control room (Fig. 4) for this switchgear is in the power station; multi-core cable interconnections between the two sites are run in a cable tunnel, part of which is a 5ft diameter spun concrete pipe. Cables carrying the low-voltage a.c. and d.c. supplies from distribution boards in the main power station are also run in this cable tunnel. Aluminium sheathed rubber insulated cable is used for all lighting, heating and socket outlet circuits.

Carmarthen Bay power station is one of the South Wales power station schemes that was taken over by the British Electricity Authority at vesting day. The scheme was initiated by the Carmarthen Bay Power Station Company, Ltd. Its design and construction was in the hands of Balfour, Beatty and Co., Ltd., and the architect was Sir Percy Thomas.

After vesting day the work was continued by Balfour Beatty and Co., Ltd., on behalf of Mr. H. V. Pugh, controller of the South Wales Division of the B.E.A. In October 1951, Mr. Pugh was appointed controller of the London Division and was succeeded in South Wales by Mr. H. J. Bennett.

Main Contractors

The main contractors are as follows:—Foundations and superstructure, river works and pump house, railway sidings, L.P. pipework and L.V. cabling, Balfour Beatty and Co., Ltd.; dewatering system, Millars Machinery, Ltd.; steelwork, South Durham Steel and Iron Company, Ltd.; chimneys and brick flues, Chimneys, Ltd.; roof decking, Universal Asbestos, Ltd.; turbo-alternators and condensers, Metropolitan-Vickers Electrical Company, Ltd.; boilers, Babcock and Wilcox, Ltd.; air heaters, James Howden and Co. (Land), Ltd.; fans, Davidson and Co., Ltd.; dust collectors, Prat-Daniel (Stanmore), Ltd.; electrostatic precipitators, Sturtevant Engineering Company, Ltd.; feed pumps, Harland Engineering Company, Ltd., and G. and J. Weir, Ltd.; h.p. pipework, Stewarts and Lloyds, Ltd.; h.p. valves, Dewrance and Co., Ltd., and Hopkinsons, Ltd.; l.p. valves, Alley and MacLellan, Ltd., Blakeborough and Sons, Ltd.; water tanks, Braithwaite and Co. (Structural), Ltd.; evaporators, Aiton and Co., Ltd.; c.w. pumps, Vickers Armstrongs, Ltd.; c.w. pump motors, Laurence-Scott and Electromotors, Ltd., and The British Thomson-Houston Company, Ltd.; c.w. screens, F. W. Brackett and Co., Ltd.; coal-handling plant, Babcock and Wilcox, Ltd.; tipplers, Strachan and Henshaw, Ltd.; stocking out conveyor, Rhymney Engineering Company, Ltd.; bunkers, South Durham Steel and Iron Company, Ltd.; ash-handling plant, B.V.C. Industrial Constructions, Ltd.; 132kV switchgear, Ferguson Pailin, Ltd.; 3·3kV and 415V switchgear, The British Thomson-Houston Company, Ltd.; generator transformers, station transformers and unit transformers, A.S.E.A.; auxiliary transformers, Hackbridge and Hewittic Electric Company, Ltd.; 132kV cable connections, Pirelli-General Cable Works, Ltd.; cables, B.I.C.C. Company, Ltd., Britannic Cable Company, Ltd., Hackbridge Cables, Ltd., Pirelli-General Cable Works, Ltd.; 132kV transmission lines, B.I.C.C. Co., Ltd.; cranes, Cowans Sheldon and Co., Ltd.; boiler control instrument panels, Bailey Meters and Controls, Ltd.; water treatment plant, Paterson Engineering Company, Ltd.; chemical injection plant, Permutit Company, Ltd.

Short Notice

Radio. Vol. II.* By John D. Tucker and Donald F. Wilkinson. London: English Universities Press, Ltd., St. Paul's House, Warwick Square, E.C.4. Price 10s. 6d.—This is the second of three progressive volumes on radio written to cover the syllabus of the City and Guilds of London Institute examinations in radio. This covers the Radio II Examination. It follows the style of the first volume, to which there are some cross references, but is more advanced throughout. There are chapters dealing with radio frequency coils and capacitors, electronic tubes, audio frequency amplifiers, radio frequency amplifiers, oscillators, power supplies, transmitters, receivers, measurements, acoustic equipment, directional aerials and radio communication. At the end of each chapter there are a number of numerical examples of answers, taken in the main from City and Guild examination papers, together with a specimen answer prepared by the Post Office Engineering Department, which serves to illustrate the subject matter. The book is well produced with clear diagrams. The symbols largely conform to standard usage, but there is some inconsistency in the use of the symbols E and V to denote electrode potentials. The subject matter included and the standard achieved is such that the book is of value to students preparing for a number of examinations in radio engineering, in addition to the City and Guilds examination on which it has been based.

Book of Reference

British Standards 1954 *Yearbook*. London: British Standards Institution, 2, Park Street, W.1. Price 12s. 6d.—This yearbook lists some 2500 British Standards current at March 31, 1954, and gives a brief description of the subject matter of each. The usual information on the membership of the Institution's General Council, Divisional Councils and Industry Standards Committees is given, together with the names of representatives on the main special committees and advisory committees. Particulars of the work in hand of all the Industry Standards Committees are also given. The British Standards under which the Institution's certification trade marks are used are arranged beneath the following headings: electrical; building; plastics; bedding and furniture; personal safety; and miscellaneous.

* Vol. I was noticed in our issue of July 18, 1952.

Stress-Relieving of Large Fractionating Column*

IN the construction of a high-pressure oil fractionating column 120ft long by 3ft 8in diameter, it was found that there was no furnace available large enough to accommodate the whole column for stress relieving. In consequence it was decided to fabricate the column in two halves which could be stress relieved separately. These were subsequently joined by a central weld which was heat-treated on site in a temporary furnace (see Fig. 1).

The schedule for heat-treatment was taken from the 1943 Code of Practice issued jointly by the American Petroleum Institute and the American Society of Mechanical Engineers. This limits the longitudinal temperature gradient to 200 deg. Fah. per foot and the maximum temperature difference at any point to 150 deg. Fah. The rate of heating above 600 deg. Fah. must not exceed 400 deg. Fah. per hour, a temperature of 1100 deg. Fah. must be reached and maintained for one hour, and subsequent cooling must not exceed 500 deg. Fah. per hour. This implied a close control of the furnace, which was achieved by the design shown in Fig. 2.

Fig. 1—120ft fractionating column showing temporary furnace for stress-relieving central weld

A brickwork duct was built around the lower half of the vessel, the construction being such that a rectangular combustion chamber was formed with an offtake into the duct, and a flue arranged at low level to relieve any excess pressure in the furnace. The upper half consisted of a sheet steel duct which rested on, and was sealed to, the lower brickwork. This duct was then covered with brickwork to form the finished structure. With a view to maintaining the required temperature gradient along the column, a ring of low-temperature insulating bricks 3in thick was placed against the interior surface for a total length of about 6ft, and a spillage of hot gases from the heating chamber was allowed to flow along the exterior surface of the vessel for a distance of some 2ft on each side of the main chamber in an annulus created by the fitting of lagged sheet steel covers held away from the shell by ¼in distance pieces.

The portion to be heated was a circumferential strip 15in wide, and the hot gases were drawn from the top of the combustion chamber into the inlet side of a high-speed axial fan and circulated around the annular space between the exposed shell surface and the ducting. This meant that the fan blades and a portion of the shaft were in the flow of the hot gas stream. In order to avoid any possibility of overheating the independent fractional horsepower motor, it was proposed to employ a vee-rope drive and to water cool the hollow fan shaft and the shaft bearings. In practice, however, the fan shaft was solid and driven direct by a motor through insulated couplings. This was not entirely satisfactory, as the conducted heat affected both the bearings and the motor during the course of the tests.

The burner equipment consisted of two "Hypact" burners, Nos. 600 and 400, each separately controlled by a quadrant cock and fed from a common gas supply pipe which carried the control equipment. The gas was fed to the burners through a constant-pressure governor and a solenoid valve, the latter being by-passed with a small valve in the by-pass pipe for adjustment purposes. The solenoid valve was operated from the electricity mains through a temperature indicator/controller, and the controlling thermocouple was sited in the hot gas stream at its first point of contact with the vessel.

In order to assess the average temperature of the heated section four thermo-couples (Nos. 4, 5, 6 and 7, shown in Fig. 2) were sited on the inner surface of the vessel around the weld. A further three thermo-couples (Nos. 1, 2 and 3, also shown in Fig. 2) were sited at appropriate points along the inner surface of the vessel away from the weld. In order to determine the rate of temperature rise No. 7 thermo-couple was connected to a temperature recorder and half-hourly readings of the remaining thermo-couples were taken by means of a potentiometer which was also used to check the recorder.

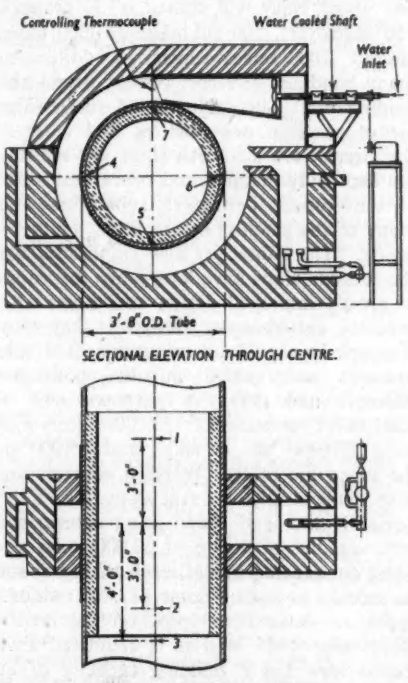

Fig. 2—Sections through furnace; numbers indicate thermo-couple positions

As rapid heating was not essential, it was decided to avoid any possible local strains due to expansion by bringing up the temperature slowly. This was done by running the No. 400 burner until the temperature rise began to slow down, then changing over to the No. 600 burner, and finally running both burners full on against control by operation of the solenoid valve from the temperature controller. The temperature gradients during the heating period are shown in Fig. 3, which also indicates the rate of temperature decrease during the vital initial cooling period.

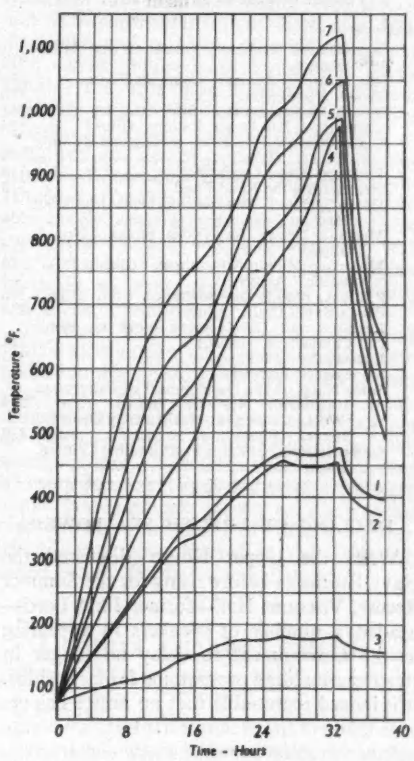

Fig. 3—Time-temperature curves of the thermo-couples indicated in Fig. 2

The gas consumption over the total heating cycle was approximately 20,000 cubic feet (100 therms). This was considered to be reasonable in view of the size of the vessel and the nature of the heat-treatment involved.

* Reproduced from Report No. 566/53 of the Industrial Gas Development Committee of the Gas Council, based on information supplied by the East Midlands Gas Board.

Two-Gang Flameproof Switch

A TWO-GANG flameproof switch which was originally developed for locomotive manufacturers by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, is now generally available. It is suitable for use in mining and similar locomotives, for head and rear light change-over control or in any situation requiring two separate switches in one case.

Machined faces of sufficient width to give flameproof protection are provided on the covers of the switch chamber and terminal chamber and the corresponding seatings on the main casting. The switch chamber contains two one-way, earthed, "Landor" rapid-make, rapid-break, single-pole flush switches. Their external operating handles and the cover of the switch chamber are fully interlocked: the cover cannot be removed when either of the switches is in the "on" position and neither of the switches can be operated when the cover is off. Four wiring terminals are provided, to enable the switches to be connected as required and for cabling the terminal chamber is drilled and tapped 1in E.T. on both sides, a solid brass threaded plug being supplied for sealing the hole that is not required.

Grey enamel provides the standard finish for the switch. The whole equipment is designed to comply with B.S. 229 and has been certified (certificates FLP 2780, group I, and FLP 2781, groups I and II).

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DECLINE OF BRITISH SEA POWER

When the Upper House discussed the Navy Estimates before rising for the Summer Recess, Viscount Hall—former First Lord—headed a number of speakers in appealing to the Government to delay no longer in starting a building programme for large ships. It is indeed regrettable that no notice has yet been taken of the present First Lord's warning eighteen months ago that a new construction programme is vital to replace our fast-ageing carriers and cruisers, if the Royal Navy is to remain a balanced and efficient fighting force. Unless we begin building without further delay we shall, by 1960, have only seven carriers capable of operating modern aircraft, and some half-a-dozen cruisers less than eighteen years old. Not one surface fighting ship larger than a frigate has been laid down since the war, and this is no doubt the main reason for the decreasing interest in the Navy and the value of sea power. Officers and men also have a sense of frustration in being called upon to maintain a purely defensive role for the Navy. When Communist aggression started in Korea in 1950, the whole of our naval effort had, of necessity, to be concentrated on the defensive; for, apart from destroyers, we had no ships capable of dealing with fast submarines, and no minesweepers able to sweep new types of acoustic mines. Indeed, the Government announced at the time that we were not in a position to safeguard our supplies from across the Atlantic without the help of the United States Navy. Since then, happily, the position in this respect has greatly improved as the result of the rearmament programme in 1951, which provided for the construction of over 150 minesweepers of new types and the building or conversion of some seventy fast frigates.

Sea communications have, however, to be safeguarded not only against submarines and mines, but also against cruisers, armed merchant raiders and aircraft. And Russia, as we have frequently pointed out in these columns, has been acquiring since the war a powerful surface fleet and naval air arm, in addition to her very large force of submarines. The Royal Navy has special responsibilities for the defence of focal areas of trade in the Eastern Atlantic, Mediterranean and Indian Ocean, but unless a building programme is begun without further delay, will be quite unable to safeguard these focal areas without again relying on the United States Navy. The seriousness of the position is indicated by the recent and somewhat surprising decision of the Admiralty to reveal full details of the strength of the Soviet Navy. By 1957, it is estimated, the Soviet Navy will consist of 30 cruisers, 150 destroyers, 500 submarines, 4000 naval aircraft, 1000 minesweepers, in addition to many hundreds of escort vessels, patrol and landing craft, &c. Nearly all these ships are of post-war construction, and most of the aircraft are jets. All ships not refitting are kept fully manned and operational, and all the cruisers, destroyers, submarines and many of the small craft are fitted for mine-laying. The Admiralty also emphasise that the Russian ships have long-range torpedoes of greatly improved design and mines with complex anti-sweeping devices; they may also well be capable of using tactical atomic weapons and guided missiles, both for offensive and defensive purposes. Of a total naval personnel of 750,000 officers and men, 270,000 are in ships and 85,000 in the naval air force. Warship construction is in hand in all the naval shipyards of the Soviet Union, and ocean-going submarines with a radius of action of 20,000 miles are being constructed inland, each taking about six months to build. Some £12,000 millions appear to have been spent on the Soviet Navy since 1945, and it is estimated that Russia now has a building capacity of at least six cruisers of the "Sverdlov" class and sixty ocean-going submarines per annum, in addition to large numbers of destroyers and small craft.

It is important to bear in mind that many of the Soviet cruisers mount 7in guns and all have large endurance and are thus very suitable for attacking trade in the oceans. How can we deal with these forces with only seven modern carriers and twenty-three cruisers, most of which are nearing their age limit? And what sort of part could the Navy take with these few ships in N.A.T.O. offensive operations in enemy waters? We have now become resigned to the fact that we are no longer the strongest naval power, but are we to be satisfied with a Navy which is inferior to the Soviet Navy—the navy of a country which has always been primarily a land power? Government spokesmen contend that, unlike the other two fighting Services, the Royal Navy does not yet see the green light. Large warships laid down now must retain their fighting value for at least twenty years and we cannot afford to build them pending more knowledge of the revolutionary developments now in progress. Are ships to have a nuclear power plant or gas turbine? Are guided missiles the most effective main armament? If so, what type and what size? These arguments would be more convincing were it not that the United States Navy seems already to have reached decisions. A fourth super-carrier—proposed for the 1954–55 building programme—is to have a nuclear power plant and plans for converting existing cruisers into guided missile carriers are believed to be well advanced. One suspects in fact that financial stringency is the main reason for the delay in rebuilding British sea power. Nor is there any urge or prodding from the nation. The need for this country to import annually 50,000,000 tons of dry cargo and 30,000,000 tons of oil, if realised at all, seems of little importance in relation to the hydrogen bomb.

OIL ENGINE BREAKDOWN EXPERIENCE

The expression "preventive" maintenance as applied to the maintenance of heavy-oil engines reminds us that an essential step in the evolution of preventive *medicine* was the recognition that there should be no interference with the recuperative energy—the *vis medicatrix*—which belongs to every organised being. The engineer is not so fortunate here as is the physician, for the reason that the machinery with which he deals has no self-recuperative faculty. If it wears—as it must—it just goes on wearing faster or slower according to the features of the design, the ingredients from which it is constructed, the duty on which it is employed and the quality of the supervision which it receives. There was a time, not long since, when an expression popular among engineers—and others—was "specialisation of function." One aspect of this meant the application of design to what appeared to be the specific requirements of given working conditions. In recent times the accent has changed and the drift is now strongly directed to using one kind of engine for services which, like rail traction and industrial power supply, are widely dissimilar.

These remarks are suggested by perusal of a paper read before the Diesel Engine Users Association by Mr. H. D. Adam, the text of which has lately been published. The title, "Preventive Maintenance from Breakdown Experience," causes a reader to look for contents which are notably practical, and this expectation is made good both by the paper itself and by the discussion following its presentation. The author—as was re-

marked by a speaker in the discussion—has had experience in examining damaged engines comparable to that acquired by the surgeon in a hospital casualty department, and he has put into this interesting paper his notes on case history. These he illustrates by photographs and drawings, some of them so graphic that we almost hear the echo of the smash. Mr. Adam does not leave us with the bare post-mortem notes, but—and this is perhaps the most valuable part of his paper—he explains the procedures which, according to his experience, are likely to remove—or at least lessen—the possibility of recurrence of such breakdown. We are not surprised to note the marked emphasis placed on lubrication, but it does surprise us that nearly two and a half centuries after the time of Newcomen, it should still be necessary to utter warnings as to the consequences of inattention to lubrication. Mr. Adam strongly emphasises the importance of taking particular care in starting and stopping, and his words in respect of fuel oil supply could well be put up as an illuminated sign in many engine-rooms. Typical of his practical outlook is a note which he includes as to the trouble caused by water and dirt getting into engine service tanks : " On investigation it has been found that the main tank drainage cock is large and difficult to operate and, if unused for long periods, it is hard to open and may be damaged and leak when closed ; as a result it is rarely used. If the valve opening is fitted with a blank flange equipped with a test cock, the valve can be operated without risk of leakage."

It might be objected that Mr. Adam has not dealt (from the breakdown and maintenance point of view) with the high-speed lightweight engine. On this type he has, however, the following note : " As regards the great difference between the slow running old type engines and the modern potted-power high speed type, I have tried to deal mostly with the medium speed type which is used for industrial purposes." In another place and referring to the determination—by assessment of risk—of the conditions of insurance against breakdown, Mr. Adam remarks that " the user who pays out to avoid trouble should receive compensation by paying a lower premium." Elsewhere he gives the following excellent advice : " Those who are wise do not accept tenders on price, but want value for money expended by obtaining a reliable, efficient plant ; first cost may be high, but from past experience we find it an excellent investment over many years, at the same time giving carefree running and satisfaction to all those connected with the undertaking." This reminds us of the oft-quoted words of John Ruskin in that place where he tells us that : " There is hardly anything in the world that some man cannot make a little worse and sell a little cheaper and the people who consider price only are this man's lawful prey." Certain it is that longevity and cost of maintenance are being examined just now with increasing circumspection. Disappointment caused by breakdown and high maintenance cost is particularly bad for the oil engine building industry at a time when, throughout the world, there is ever increasing development of hydro-electric power. It may seem to many, as it does to us, that the attention of engine manufacturers ought to be specially directed to the problem of producing engines which will lessen the burden on maintenance men. The user is not concerned with the technique of repetition production. What he seeks is trouble-free performance from engines in which the problems of the maintenance men are recognised and catered for. There will always be the need for industrial engines of high stamina and for high-speed lightweight engines, but it is necessary to use these specific types in the services for which they are best adapted. We sometimes hear it argued that an engine should be so designed that after a specified number of running hours it will collapse gracefully into scrap. The fallacy here is that the buyer of such an engine is likely to find that there is no certainty as to when, where and under what circumstances the collapse will take place. Meantime, it becomes ever more urgent that engine manufacturers—and engine users—should give consideration to advice (and warnings) such as those offered to them in Mr. Adam's paper, which, as we read, earned for its author the award of the Percy Still Medal.

Literature

The Steel Skeleton. Vol. I, *Elastic Behaviour and Design.* By J. F. BAKER. London : Cambridge University Press, Ltd., Bentley House, 200, Euston Road, N.W.1. Price 42s.

IN science the progress of theory and practice go hand in hand. New theories are suspect if they cannot be substantiated by experimental evidence and conversely experiment alone is never wholly satisfactory if a theory cannot be found to explain observed phenomena. In the pure physical sciences theory often takes the lead; rarely so in engineering. Indeed, complex structures were erected long before the development of a theory for computing stresses. Practice, however, showed that structures built according to certain concepts stood up and this quite naturally was sufficient justification for repeating the design. Gradually practical design rules were established which later were to provide a basis for the classical methods of structural theory. At best these methods were only theoretical models—no engineer really believed that stresses in a complex redundant frame behaved as suggested by Clapeyron's equations. Nevertheless, structures so designed did not fail and the elastic model based on the hypotheses of St. Venant, Hook and Maxwell was universally adopted. A variety of mathematical methods were devised for its solution, the choice of method depending largely on the mathematical ability of the engineer and the time he was prepared to expend on calculations. Generally the more advanced the calculations, the closer the limits of error, the smaller the factor of safety and the greater the economy of materials.

Although building specifications in all countries were based on this elastic model, it was realised as far back as 1929 that the classical methods of structural design did not exploit to the full the excellent qualities of steel as a building material. As a result the Steel Structures Research Committee was set up to investigate the validity of accepted structural theory. This was the first attempt at a practical study of steel structures based on large-scale experiments to determine the actual behaviour of steel frames submitted to external forces. The two volumes of *The Steel Skeleton* are planned to give a detailed account of research on steel structures undertaken in Great Britain during the last twenty-five years, and, in particular, they will report on the work of the Steel Structures Research Committee.

Vol. I, *Elastic Behaviour and Design*, describes fully the tests which were carried out on experimental frames, hotel and office buildings and a block of residential flats. The results obtained are discussed in detail, notably the behaviour of beam-to-stanchion connections and the behaviour of stanchion lengths. Critical loading conditions are examined and design methods for beams and stanchions are developed. Still within the compass of the elastic theory, these methods give much better approximations than those prescribed in B.S. 449, and they are very considerably simpler than the classical methods of evaluating stresses in highly redundant structures.

Professor Baker gives us a stimulating critical examination of existing specifications and a rational approach to the design of steel structures. He is the first to make a determined effort to find out how steel structures do behave instead of suggesting how they should behave. This book should be studied by every structural engineer and its contents assimilated in preparation for the study of the revolutionary methods of plastic design which are to be published in Vol. II, to be called *Plastic Behaviour and Design.*

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SMOKING CHIMNEYS AND SULPHUR

SIR,—Your very wise leading article of August 27th prompts me to make two independent points in connection with the subject of atmospheric pollution.

You rightly mention smokeless zones and their introduction is to be commended in every way. However, I believe that for at least another decade we shall have to be content if worthwhile advances are made towards smoke reduction only, as opposed to total elimination. The latter is an ideal which will be absolutely unattainable even in the near future.

The problem to be faced is extremely complicated and has many aspects, but the availability of suitable fuel presents the greatest headache. Both the Simon and Ridley Committees have endorsed that the main winter space-heating load must be carried with solid fuel, and from the point of view of smoke creation, the ordinary household grate is the biggest offender. Between them, they burn well over 30,000,000 tons of raw bituminous coal each year and the vast majority of the 16,750,000 private homes in this country contain several grates in each.

Ten years ago, the Simon Committee suggested that this amount of coal should be burnt smokelessly each year by 1965, but we have advanced very little towards this goal. In 1952, 750,000 tons of anthracite, 1,000,000 tons of dry steam coal, 3,000,000 tons of coke, and about 500,000 tons of manufactured products made up the domestic quota of smokeless fuel. It is true that the production of all these varieties of fuels is being increased very slowly, but the greatest hope lies with coke.

At the National Smoke Abatement Society Conference in Glasgow last year, representatives of the Gas Industry indicated that within ten years sufficient coke would be available to meet all the domestic requirements in the worst areas in the country. It is to be hoped that this forecast is not unduly optimistic, in spite of criticism levelled at the reactive properties of this fuel.

Of course, low temperature coke can be burned

in an old-fashioned grate, but who is going to pay for the millions of modern appliances which are obviously desirable and which are, in fact, generally essential for use with smokeless fuels, assuming that the latter eventually become available in the desired quantities ? Again, how many householders will be willing to forego the pleasure of watching their nice cheery flames ?

The problem of pollution by sulphur compounds should be treated as a separate problem. The B.E.A. policy of providing tall chimney stacks is generally considered to be the best solution in the light of present knowledge. Apart from the initial cost and high operating expenses, flue-gas washing does introduce some less obvious economic problems. However, much is likely to be said about this subject by a number of experts who are to address the conference on "Sulphur Removal and Recovery from Fuels," which has been organised by the Institute of Fuel and which is to be held in London early in October.

JOHN FOX

Hove, Sussex, August 30th.

HYDRODYNAMIC LUBRICATION OF ROLLER BEARINGS

SIR,—Mr. Lewicki's paper in your issue of June 25, 1954, contains an interesting application of the elastico-hydrodynamic theory of lubrication, discussed elsewhere by Professor Blok (*Annals N.Y. Acad. Sci.*, 1951, 53, 779–804). As Mr. Lewicki's contribution is essentially to place earlier qualitative ideas on a quantitative basis, it is unfortunate that his analysis should be marred by several errors.

The most serious error in the paper arises from the method adopted to determine the inclination of the flat, leading to the incorrect conclusion that δ is always zero and that α is constant. δ and α are fully determinate from the expressions for N, T and L, and consideration of the equilibrium of external forces acting on the cylinder ; for the system shown in Fig. 6 it is obvious that δ must have a finite negative value, the moment of T_f about the axis not being negligible. The method used by Mr. Lewicki, however, involving the derivation of equations (21)–(23) from the (incomplete) system of forces in Fig. 5 is meaningless. It is also quite unnecessary, because the relationship between hydrodynamic and elastic stresses has been predetermined by the initial assumption of the mode of elastic deformation. If a closer approximation were required then a method such as that of Weber (cited by A. Cameron, *Journal Inst. Pet.*, 1952, 38, 614) might be employed.

There appears to be some inconsistency in the consideration of conditions outside the flat. In one place it is assumed "that there are no significant normal forces beyond the flat" and these forces are neglected in obtaining the total load N (equations (17) and (36)), yet the normal and tangential forces on the curved surfaces appear in equations (30) to (33). An alternative, and perhaps preferable, approach would have been to assume throughout that the hydrodynamic forces outside the flat were truly negligible and that both the hydrodynamic as well as the elastic stresses are confined to the region of deformation. This would have considerably simplified the analysis without appreciably affecting its validity.

A number of lesser criticisms might also be made, such as the quite unjustified omission of tangential stresses from equation (30), and the curious derivation of equations (13) and (31).

The basic concepts of the elasto-hydrodynamic theory of lubrication appear to be sound, for it is known that elastic and even plastic deformations can be produced by forces transmitted through intact lubricating films (e.g. Tabor (*Proc. 7th Intl. Cong. App. Mech.*, 1948, 4, 339)). It may be of some interest, therefore, to repeat the analysis along the lines indicated. Similar assumptions may be made, except that the lubricant film is assumed to act over the surface of the flat only, i.e. that the inlet pressure at $h=h_2$ is zero. Standard hydrodynamic theory for a bearing with both surfaces moving with velocity U in their own planes gives expressions for total load N, frictional drag T and the position of the centre of pressure δ as follows :—

$$N=\frac{12U\eta BL^2}{h_1^2(\alpha-1)^2}\left\{ln\alpha-2\left(\frac{\alpha-1}{\alpha+1}\right)\right\} \quad . . . (1)$$

$$T=\frac{6U\eta BL}{h_1(\alpha-1)}\left\{ln\alpha-2\left(\frac{\alpha-1}{\alpha+1}\right)\right\} \quad . . . . (2)$$

$$\frac{\delta}{L}=\frac{1}{2}\left\{\frac{3-(\alpha^2+4\alpha+1)ln\alpha/(\alpha^2-1)}{ln\alpha-2(\alpha-1)/(\alpha+1)}\right\} \quad . . (3)$$

It may be noted that the pressure gradient is everywhere double that for a slider bearing of similar dimensions, and that the centre of pressure is the same as for a similar slider bearing.

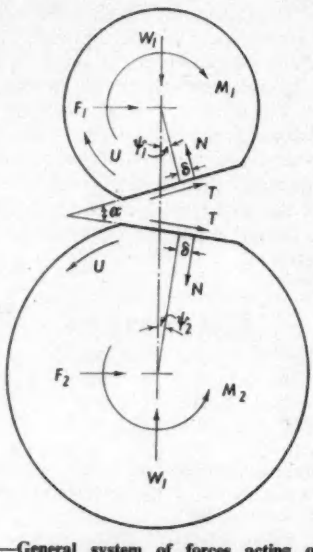

Fig. 1—General system of forces acting on two cylinders rolling together

If the equilibrium of the general system shown in Fig. 1 is considered, then

$$N=W \quad . . . . . (4)$$

$$F_1=-N.\frac{a}{2}\left(\frac{R_1-R_2}{R_1+R_2}\right) \quad . . . . (5)$$

$$F_2=-N.\frac{a}{2}\left(\frac{R_2-R_1}{R_1+R_2}\right) \quad . . . . (6)$$

$$M_1=N\left(\delta+R_1\frac{a}{2}\right) \quad . . . . . (7)$$

$$M_2=N\left(\delta+R_2\frac{a}{2}\right) \quad . . . . . (8)$$

while from elasticity theory for cylinders of the same material, Poisson's ratio ν,

$$L=\sqrt{\frac{W}{BE}\cdot\frac{32R_1R_2}{R_1+R_2}\cdot\frac{1-\nu^2}{\pi}} \quad . . (9)$$

These equations are sufficient to determine the film thickness and coefficient of friction under all conditions of operation to which the theory is applicable. Limitations of space precludes a full discussion here of the implications of the revised theory. However, taking the case considered by Mr. Lewicki, i.e. a steel cylinder rolling on a steel plane under the action of a force applied to its axis, then $M_1=0$, $R_2=\infty$, and

$$\delta=-R_1\frac{a}{2} \quad . . . . . (10)$$

(It may be noted that this relation is also obtained when a cylinder is rolled between two planes, e.g. Fig. 2). Substituting in equations (1), (3), (9),

$$\frac{6E}{2\cdot15^2}\cdot U\eta R_1\left(\frac{B}{W}\right)^2=\frac{[3-(\alpha^2+4\alpha+1)ln\alpha/(\alpha^2-1)]^2}{[ln\alpha-2(\alpha-1)/(\alpha+1)]^3} \quad . . . . . (11)$$

which shows how the film thickness ratio α varies with the conditions of operation. h_1 may then be determined from equation (1) and the coefficient of friction from

$$\mu=\frac{F}{W}=\frac{h_1(\alpha-1)}{2L} \quad . . . . (12)$$

The conclusion that α varies with the conditions of operation invalidates much of Mr. Lewicki's subsequent argument. It is interesting to note that a similar conclusion was reported by Blok (*Journal Inst. Pet.*, 1952, 38, 673) for a rather similar system, though his analysis was not given in detail. There still remains some doubt whether the assumption of a flat is a sufficiently close approximation to the probable deformation, but that is outside the scope of this letter. The reader is referred to Blok's papers for a fuller discussion than is possible here of elasto-hydrodynamic lubrication theory.

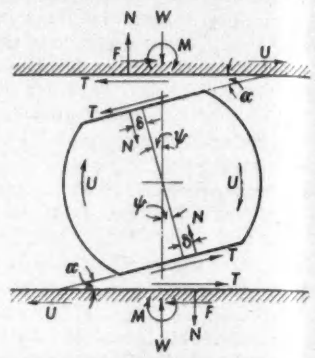

Fig. 2—General system of forces acting on a cylinder rolled between two planes

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Mechanical Engineering Research Laboratory,
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IMAGINATION AND THE RAILWAY INDUSTRY

SIR,—Many readers no doubt have perused with interest the article on "Imagination and the Railway Industry," published in your journal on August 13th, but the majority of them would consider the suggestions contained therein as refinements for British Railways at the present time.

Imagination has been sadly lacking for many years among those who have been, and are to-day, responsible for the running of railways in this country, and their attention should not be distracted by such unimportant problems. In view of the deplorable financial position and unrest among employees in our railway industry, the first and most important things which should exercise the minds of the managers and officers are ways and means of establishing a financially sound and efficient industry which can make a useful contribution to the economy of this country.

The British Railways could better employ their imagination at the present time in organising efficiently the traffic, goods, signalling, civil engineering, mechanical and locomotive engineering departments ; also, in studying ways and means of breaking down outdated prejudices among officers and which so much hamper efficient and economic working.

The refinements suggested in the article would immediately induce the persons responsible for these services within the industry to apply for additional staff to write suitable literature, and then further staff for printing and distribution. The revenue from such a scheme would be nil, and therefore an extra charge would be imposed on the already insufficient total revenue. The public would much prefer to have clean trains running on time, cheaper and better meals on trains, civility and service from all grades of railway staff and, above all these things, cheaper fares.

W. T. WILKS

Chorley Wood, August 26th.

Tennessee Paper and Pulp Mills

No. I

The official opening will take place on October 9, 1954, of the Tennessee Mills of Bowaters Southern Paper Corporation. Constructed in two years at a cost of 60,000,000 dollars, the mills are designed to produce 130,000 tons of newsprint and 55,000 tons of kraft pulp annually, which makes them the largest of the three newsprint mills in the southern United States. The entire newsprint production has already been purchased for the next fifteen years by over a hundred publishers in the southern states, while the output of pulp will be exported to the United Kingdom for use in the manufacture of newsprint and of printing and packaging papers.

THE history of the Tennessee Mills goes back to 1947, when it was realised that the Bowater mills at Corner Brook, Newfoundland, would not be able to cope with the continually increasing demand from the United States. Accordingly it was decided to establish a mill in the southern U.S.A., and thus make available more of the Canadian output for the north. An extensive survey led to the selection of the present site at Calhoun on the Hiwassee River, a tributary of the Tennessee, where there are ample supplies of the three main requirements of a paper mill, viz., water, cheap power and wood. The new plant is well served by road, railway and inland waterways, and there is local labour available, with housing and amenities already in existence.

The wood supplies are mainly Southern Pine, which matures for pulp in twenty-five to thirty years, compared with seventy to eighty years for similar trees in the north. Its chief disadvantage, a liability to decay in storage, can be overcome by storing the logs under water, and this is the method which has been adopted. In addition to other sources of supply, by the time its afforestation programme is completed, the company will itself own some 200,000 acres of forest in Tennessee and neighbouring states.

In full production, the mill will use about 40,000kW, of which one-half will be generated, the other half being bought from the Tennessee Valley Authority. The filtration plant will supply 25,000,000 gallons per day.

Construction work was begun in June, 1952, and was completed two years later. The production of kraft pulp was started in May of this year, and the first quantities of newsprint were delivered towards the end of July.

The erection of the factory was planned and supervised by J. E. Sirrine Company, with Frazer, Brace and Roane-Anderson as general contractors. Thirty-eight firms were engaged as sub-contractors, the maximum labour force totalling about 2360. Equipment was supplied by 119 firms, chiefly from the United States, but also from Canada.

Construction of Tennessee Mills

Area of site	1,800 acres
Excavations :	
Log pond	260,000 cubic yards
Process waste system (Reservoir, primary clarifier, sludge disposal basin.)	520,000 cubic yards
Total moved	1,100,000 cubic yards
Piles driven	7,200
Concrete :	
Foundations	46,000 cubic yards
Log pond	4,060 cubic yards
Filtration plant	8,780 cubic yards
Total	65,300 cubic yards
Structural steelwork	8,125 tons
Masonry work :	
Bricks	1,900,000
Tiles	862,000
Glass blocks	30,000
Equipment, excluding boilers	12,500 tons
Construction force (peak) :	
J. E. Sirrine Company (consultants)	30 men
Frazer, Brace and Roane-Anderson (general contractors)	877 men
Sub-contractors	1,450 men
Total	2,357 men

The plant is designed for an annual output of 130,000 tons of newsprint and 55,000 tons of either bleached or unbleached kraft pulp. This involves a daily consumption of some 900 cords of pine, 20 tons of salt cake, 8 tons of caustic soda, 8 tons to 18 tons of chlorine, and 14 tons of lime. Newsprint alone consumes a daily quantity of 360 tons of ground wood and 120 tons of bleached pulp ; output of pulp, including that for sale, is approximately 312 tons per day. The news furnish requires about 4000 gallons of 32 deg. Baumé liquid alum per day, in addition to 1200 gallons for water treatment.

It is envisaged that approximately 750 men will be employed, with another 700 on wood production, involving an annual wages bill in the area of 7,000,000 dollars.

The layout of the plant is shown in Fig. 2, while Fig. 1 gives an aerial view.

Wood Handling and Preparation.—Delivery of the pulpwood is by river barge, railway and lorry. Barges are unloaded by gantry crane, and railway trucks may be unloaded by the same method, or more quickly directly into a wood pit by an electric rake. Lorries can be unloaded by either of these means, or manually, and in addition a crawler crane is provided to assist during peak periods. Shipments of chips can also be handled by the gantry, or by special tipping devices.

Two multi-chain conveyors feed the logs, either directly from the unloading point or from the wood pit, to an elevated continuously revolving turntable 60ft in diameter, where final sorting according to species takes place. The logs are removed by hydraulically-operated blades and are fed to the three barking drums. These are of the suspended type, and measure 12ft in diameter by 45ft. After removal of the bark, the wood is placed on the lower end of one of two " figure eight " conveyors, which take it to the top level at the centre of the storage pond. There it falls on to a 40ft diameter turntable, and is scraped off on to a special conveyor which places it in a semi-circular pile about half the radius of the pond. Recovery is by means of two gantry cranes equipped with special grapple. The logs are then placed on the lower end of one of the two return conveyors and arrive at the high level at the wood room. The reason for duplicating the arrangements is the need for keeping wood for mechanical pulp and for chemical pulp separate. The log pond has an underwater capacity sufficient for 30,000 cords of wood.

The wood room is equipped with a 40ft diameter turntable on to which the logs are discharged at two different points, so that wood for mechanical pulp can be scraped off into the butting saw, or if found unfit, can be passed on, and together with the chemical pulp wood, can be discharged into the chipper chute. Alternatively, logs can be returned either to the barking drums or to the log pond.

Mechanical Pulp for Newsprint.—After sawing, a flume, 1900ft long, carries the logs to the grinder room, where they are picked up by one chain conveyor and transferred to another, which feeds them at the proper rate to the apron conveyor

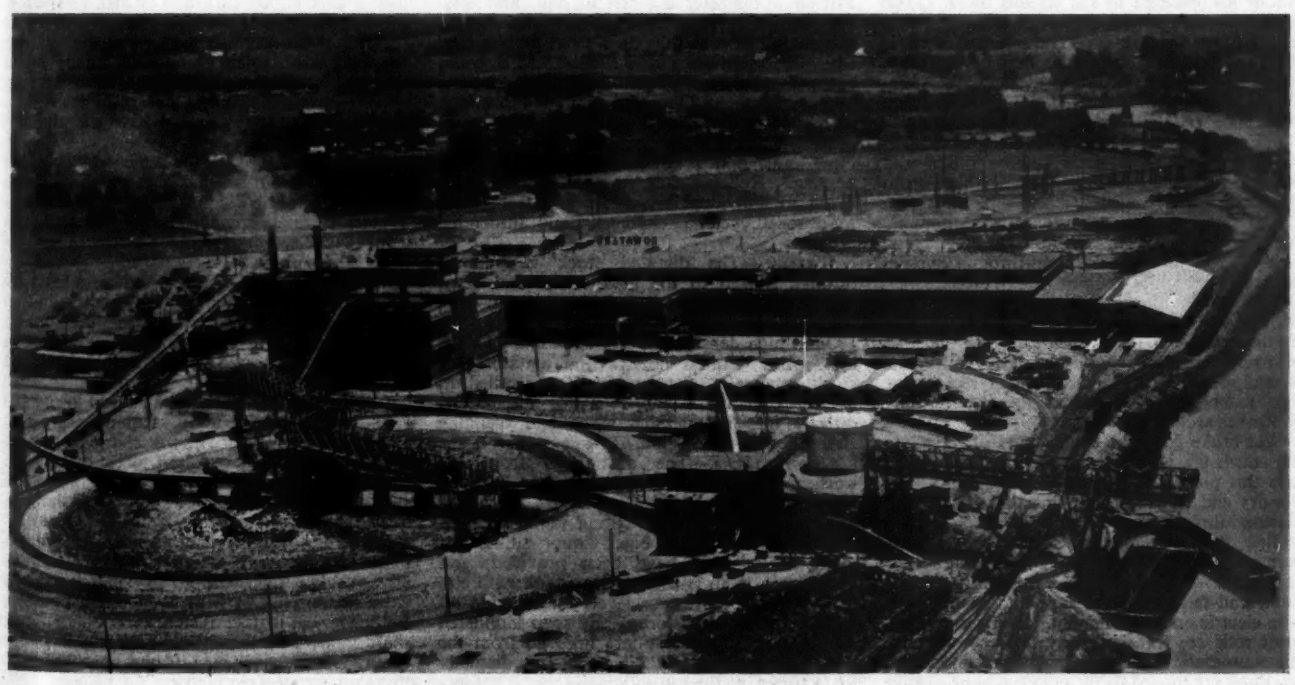


Fig. 1—Aerial view of newsprint and pulp mills at Calhoun, Tennessee. The plant is equipped to produce 130,000 tons of newsprint and 55,000 tons of kraft pulp per year

on the grinders themselves. There are eight large grinders, each powered by a 4500 h.p. synchronous motor and hydraulically operated.

The stock preparation equipment consists of two bull screens, consistency control equipment, and four primary and one secondary centrifugal screens. Bull screen rejects are broken up by a hammer mill and together with the screen tailings are further treated in three drainers and disc refiners. Ten 12in primary and ten 4in secondary "dirtecs" units remove shives and dirt from the pulp, and six groundwood deckers thicken the stock for storage.

There are two lines of equipment in the stock preparation room, one for each paper machine, each consisting of two jordans for the refining of bleached kraft, one small broke jordan and one vacuum "saveall" for clarifying the white water from the machine and for thickening the broke.

Five screens and one vibrating screen are used for the final screening of the stock.

Paper Machines.—Each of the two newsprint machines produces paper in a width of 252in at speeds of up to 2000ft per minute. Stock and

basement, which has room for 18,000 tons, and from where lift trucks can load the rolls on to lorries.

Chemical Pulp.—Wood for chemical pulp is chipped and transferred to a surge bin, after which it is passed through a pair of screens. Oversize chips are rechipped and blown back to the surge bin, while the fines are stored and subsequently burned together with the bark and fines from the butting saw. Chips of correct size are stored in silos, of which there are three. They are then discharged on to a conveyor fitted with an automatic weighing device, and are passed to the digester building, where a second conveyor equipped with trippers feeds the digesters.

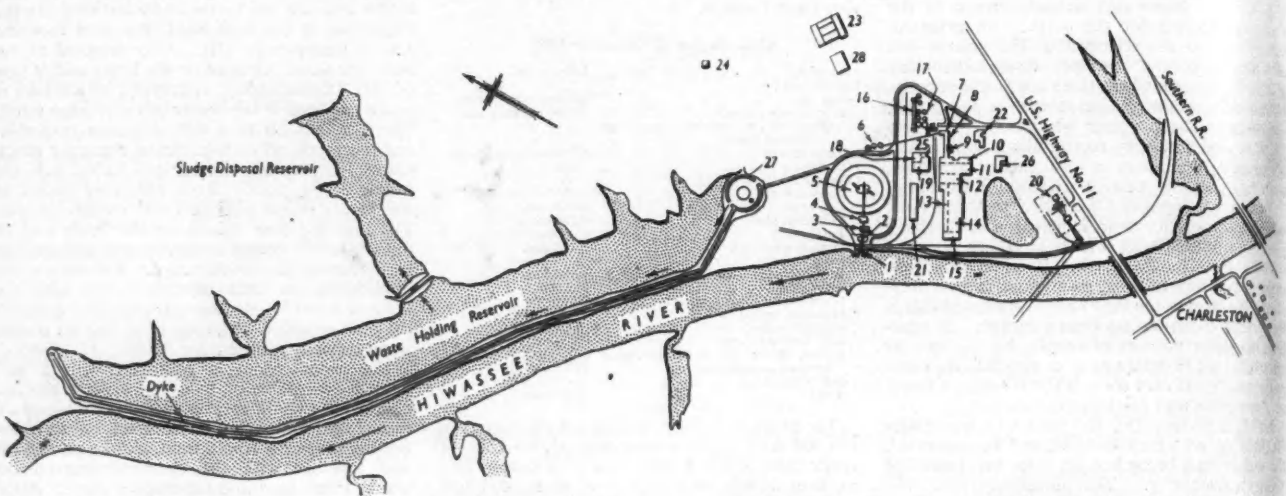
Equipment has also been provided for dealing with purchased chips, which are discharged from the barges by clamshell bucket or dumped directly from hopper cars into a concrete pit, from where they are subsequently removed by dragline and put on a belt conveyor which carries them to the surge bin.

Digesters.—There are five digesters, each

discharged by gravity into the foam tank. Weak soap is separated there and also discharged to storage. Rejects from the preknotter are discharged into the black liquor measuring tank, 9ft 6in diameter by 20ft high, which is provided with an agitator and a special pump for returning the knots to the digester, together with the black liquor fill.

White liquor for the digesters is obtained from a tank 9ft 6in by 20ft set above the digester room, which receives its supply from the recausticising plant storage.

Screen Room.—The washed stock is pumped from the surge tank at ground level after the high density storage, to a consistency regulator and a primary constant level mix tank feeding two primary centrifugal screens, the accepted stock from which discharges by gravity to two 9ft 6in by 10ft valveless type thickeners, and thence into a screened stock chest. Rejects from these primary screens discharge into a tank 8ft by 18ft, from where they are pumped to another regulator and mix tank and then to a secondary screen. The accepted stock from this screen discharges



1—Gantry crane.
2—Turntable.
3—Barking drums.
4—Wood room.
5—Wood pond storage.
6—Chip storage silos.
7—Digesters.
8—Wash and screen rooms.
9—Bleach plant.
10—Log grinder room.
11—Stock preparation.
12—Stock preparatory mixing.
13—Pulp dryer.
14—Machine room.
15—Storage and shipping.
16—Lime kiln.
17—Causticising.
18—Recovery.
19—Power plant.
20—Primary substation.
21—Storage building.
22—Facilities building.
23—Filtration plant.
24—Club house.
25—Evaporators.
26—Administration building.
27—Waste settling basin.
28—Reservoir.

Fig. 2—Layout of newsprint and pulp mills at Calhoun, Tennessee

colour are metered to the screens by a 12,000 g.p.m. centrifugal pump and dilution water is added from the savealls. The screened stock is then collected in a deaerating flume and further diluted before being pumped by a 17,000 g.p.m. pump to the pressurised header box equipped with slice of the latest design. The wire of the Fourdrinier machine is 116ft long and is equipped with table rolls, suction boxes and savealls for separating the wire drainage from the wire shower water.

The press section consists of an automatic suction pick-up roll, suction transfer press, wringer roll and two straight-through suction presses.

The dryer section is made up of four sections with a total of fifty-five paper dryers, each 60in in diameter. The eight-roll calender stack is of open construction and the heavy duty reel is equipped with the latest type of reel brake. The machines are powered by electronically controlled sectional drives.

Wet broke from the couch flows directly into the couch pit, and press broke is also delivered into this pit, which is fitted with agitators. At the dry end of each paper line there is a broke disintegrator, the discharge from which is controlled by extractor plates, correct dilution being maintained by pressure type consistency regulators. The machines are fitted with transite hood and felt drying systems, and each has its own electric crane for handling the reels. Newsprint rolls are transferred by floor conveyor to the automatic wrapping machine and after weighing are moved to the eighteen-hour storage space. They can then be brought by floor conveyor to the railway trucks or taken into the

11ft 6in in diameter and 43ft 3in high, and holding 3300 cubic feet. Space is provided for the installation of a sixth. Built from firebox steel to the specifications of the 1949 A.S.M.E. code, each has a shell 2in thick to resist corrosion and weighs 62 tons. Discharge is to a blow tank with capacity for three blows. The blow steam is passed through a cyclone at the head of the blow tank and is then recovered for water heating. Relief steam from the digesters is taken to individual separators and from them to a relief cyclone, condenser and turpentine decanter.

Washers.—The digested stock is pumped through a trap to the preknotters and from there to the three 8ft by 16ft vacuum type washers. From the final washer it goes to a 100-ton high density steel storage tank. This is fitted with dilution nozzles and agitators for stock removal. Consistency is controlled at 3½ per cent by a pan regulator discharging directly into an agitated surge and blending chest.

Liquor Tanks.—The drop legs from the washers discharge to a weak liquor tank 30ft diameter by 35ft; an intermediate tank, 32ft diameter by 35ft, and a strong tank, 34ft diameter by 35ft. Three black liquor tanks, 25ft diameter by 30ft, have been provided, and adjacent to them is a weak soap tank with collecting points at various levels for drawing off and transferring to storage any soap laundered off the black liquor. Foam lines go from the liquor tanks to a 60ft high and 15ft diameter foam tower, at the top of which there is a foam breaker. Soap and excess liquor are laundered off in the strong tank by a screw skimmer and

into a tank 8ft by 18ft, and is then returned to the screened stock chest or passed directly to the pulp dryer machine chest. The tailings from the secondary screen go to a secondary rejects tank, 8ft by 18ft, and from there through a magnetic separator, drainer and disc-type refiner, to the primary rejects tank for recirculation and rescreening in the secondary system.

Bleach Plant.—From the screened stock chest in the wash room basement, as much pulp as it is desired to bleach is pumped at regulated consistency through brushing jordans to a tonnage control unit serving the chlorinators of a three-stage bleach plant.

The chlorination stage consists of a tile-lined steel tower, 18ft diameter by 61ft high, with two-tier arrangement of rubber-lined steel circulators arranged in two tiers and a launder at the top of the tower having a rubber-covered skimmer.

Chlorinated stock is pumped to an 8ft by 14ft rubber-covered single valve vacuum washer, with shredder and conveyor for discharging through the high density double shaft mixer of cast iron to a caustic extraction tower. This is of unlined steel, 10ft diameter by 47ft high, and has one circulator made of cast iron and stainless steel.

Stock at the bottom of the caustic tower is diluted to about 2½ per cent consistency by nozzles. It is then pumped to a cast iron single valve vacuum washer with shredder and conveyor for delivery at high consistency through a double shaft mixer to a steel, tile-lined, hypochlorite tower, 17ft diameter by 17ft high, provided with two stainless steel circulators.

At the bottom of the hypochlorite tower, the high density stock is diluted by nozzles and

pumped to an 8ft by 14ft final vacuum washer with rubber-covered repulper, this washer being arranged for use with a future SO_2 stage, should the bleach plant be expanded.

Stock from the final washer passes through a pan consistency regulator which discharges directly into an agitated low density tile storage tank, 16ft diameter by 18ft high. From these it can be pumped either to the newsprint mill or to the pulp dryer, as desired.

The upper part of the building from the washer floor up is totally enclosed and is pressurised to eliminate corrosion, with exhaust fans for the removal of vapours from the washers and towers. Filtered air is provided for air sweeping the instruments, motors and controls. Effluent from the chlorination and caustic stages is carried to a tile foam tower, which receives also exhaust fumes and foam from the seal pits. A glazed partition on the operating floor encloses the control instruments, test laboratory and office.

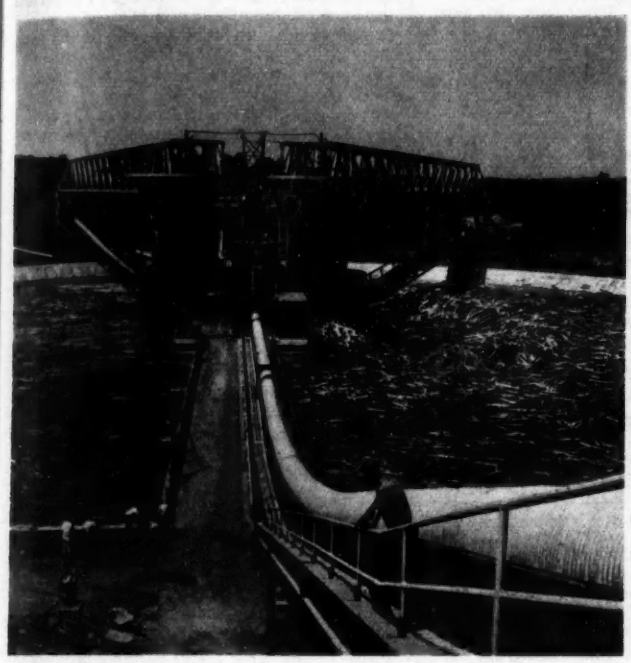


Fig. 3—Log storage pond for 30,000 cords of pulp wood, with conveyors and gantry cranes. Behind the pond is the wood room and to the right of it the wood pit

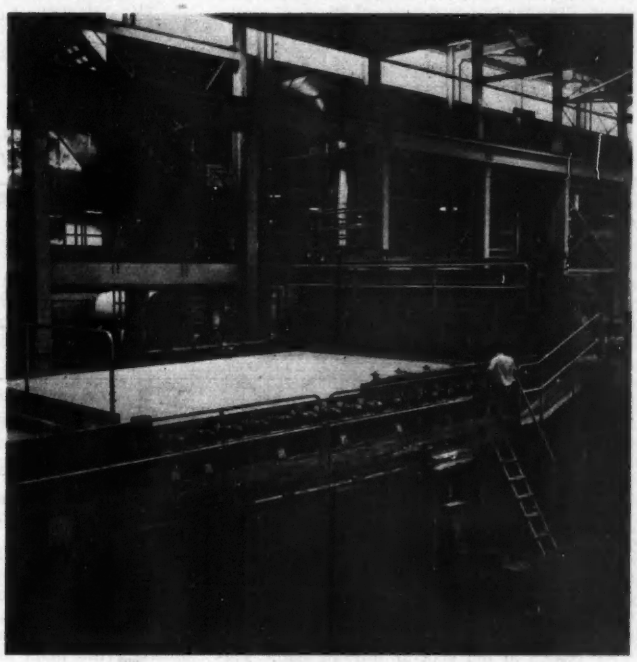


Fig. 4—One of the two Fourdrinier newsprint machines, has a wire width of 252in and works at speeds up to 2000ft per minute

While the present plant is a three-stage one for semi-bleached pulp, full provision has been made for adding another caustic, hypochlorite and SO_2 or chlorine dioxide stage should the mill desire to manufacture full bleach.

Pulp Dryer.—For the drying of the unbleached or bleached pulp for sale, a combination high density feltless wet machine and a hot air dryer is used.

The wet machine has a vacuum forming cylinder, 8ft diameter and 156in face width, and three air-loaded press rolls. The first main press has a grooved cast iron top roll and bottom roll which is followed by a two-drum dryer section of 60in diameter, and a second press similar to the first.

The dryer is built to trim 156in and receives the pulp from the second press. Pinch rolls feed it into the upper section which is divided into nine passes, with the exit at the bottom. Forty fans circulate the heated air.

Filters purify the make-up air, and fans have also been provided for cooling the vestibules. One fourteen-section economiser, arranged for double stage effect, is mounted on the roof over the dryer and supplies some water heating.

The wet machine and the conveyors of the pulp dryer are driven by d.c. motors, with the several sections synchronised and receiving their current from a single motor generator set.

Equipment for cutting, laying and conveying the pulp consists of a heavy-duty cutter arranged to furnish from a 156in nominal trim five pulp sheets, 31½in by 25½in, and three 47in by 53in wrappers. The cutter is driven by a d.c. motor in conjunction with the dryer, and pulp coming from it is delivered to the lay-by by a series of narrow belts. The sheets are ejected from the tape unit to form vertical stacks and accumulated on the belt conveyor and lowering table. When the requisite number of sheets has been reached, the table descends to its bottom position and discharges the stacks on a conveyor. The table then rises to catch the pulp sheets accumulated during this operation on automatic fingers.

From the lay-by, conveyors carry the stacks of pulp through a single downstroke baling press. The press platen is grooved so that stacks of pulp can be tied in the press. A gravity roller conveyor leads to a lowerator stacker, which delivers the bales to a 30ft long storage conveyor in the basement.

A tile chest with a propeller type repulper receives wet broke from the wet machine, and a dry pulp broke disintegrator is installed in the basement at the cutter to receive dry broke.

Over 800 tons of pulp bales can be stored in the basement, from where they are taken by lift trucks to a train shed for shipment.

Steam Generators.—A careful economic study of the proper primary steam pressure and temperature resulted in the selection of 875 lb per square inch gauge and 825 deg. Fah. One of the limiting factors in the determination of this pressure is the location of the mill in the low cost T.V.A. power region.

Steam at this pressure and temperature is produced in one recovery boiler, one bark-burning boiler and two power boilers.

The recovery boiler has a twenty-four hour dry solids capacity of 950,000 lb, or an average steam production of 123,200 lb per hour. A twin electric precipitator is located at the discharge of the induced draught fan.

The bark-burning boiler is capable of producing 125,000 lb of steam per hour, with either bark or natural gas firing. Under normal conditions there is enough bark to obtain about 68,000 lb of steam per hour. Only when one of the power boilers or the recovery boiler is out of service is it necessary to fire natural gas in the bark boiler for additional steam.

In front of the bark boiler above the firing aisle is a bark storage bin of 6000 cubic feet capacity. Bark is fed from this bin into the spreaders by screw conveyors placed across the bottom.

Each of the power boilers has a capacity of 150,000 lb per hour, and is fired by natural gas, with provision for oil firing during periods of natural gas shortage. In normal circumstances, these boilers share whatever load is required in excess of the bark and recovery production. Provision has been made for the possible future addition of coal bunkers and pulverisers, and the furnaces are provided with hopper bottoms to permit the use of pulverised coal without major alterations. The boilers are equipped for burning oil as an alternative fuel.

Turbo-Generators.—In order to obtain topping power from the process and heating steam, two turbo-generators of 10,000kW capacity each were chosen. Turbine No. 1 has throttle conditions of 850 lb per square inch gauge and 825 deg. Fah., automatic extraction at 50 lb per square inch gauge, and a condenser for 2½in Hg. Turbine No. 2 has the same throttle conditions, with automatic extraction at 150 lb per square inch gauge and 50 lb per square inch gauge back pressure.

Steam Distribution.—Two steam pressure levels are needed for the mill facilities, viz., 150 lb and 50 lb per square inch gauge. Extraction and exhaust steam taken from the turbines is fed to 150 lb and 50 lb per square inch gauge headers respectively. From these headers steam is taken for the mill and for whatever station service is required. Desuperheaters are located at the mill take-offs to reduce the temperature to just above saturation.

Linking the 850 lb, 150 lb and 50 lb per square inch gauge headers are lines containing pressure-reducing valves. These by-pass lines are for the purpose of insuring flexibility under any forseeable conditions.

Within the power house there is a 5 lb per square inch gauge header, with a by-pass connection from the 50 lb per square inch gauge header. Steam for the No. 1 feed-water heater is taken from this 5 lb per square inch gauge header.

(To be concluded)

DIESEL ENGINE PARTS LIST.—We have received from Davey, Paxman and Co., Ltd., a copy of the company's special priced parts list for its RPH. Series II diesel engines. The list is carefully indexed and the various components and systems are grouped in sections under letters of the alphabet. Each section includes line drawings and exploded views of the various parts which are clearly numbered and related to a list containing the engine part number, against which a price is quoted.

Construction of the Bank of England Printing Works

The Bank of England's new printing works, at present under construction at Debden, in Essex, consists of a number of reinforced and prestressed concrete buildings, of which the main halls are of considerable interest to the structural engineer. The main hall, consisting of prestressed concrete arches spanning 125ft and carrying north light shell roofs, and the general printing hall, a balanced cantilever and shell structure, are described here.

AN industrial building of unusual design is at present under construction at Debden, on the London County Council's industrial estate there. It is being built for the Bank of England and will eventually replace the Bank's printing works at St. Luke's, Old Street, E.C.1., thus providing more accommodation and modernised plant. The structural design of this new works is original in its conception, illustrating the possibilities of modern techniques of concrete construction; the principal halls have shell roofs, which are carried by prestressed concrete members—arches in the main hall and cantilever beams in the general printing hall. Precasting and in-situ work have been combined in different ways in the different halls, to give repetitive building procedures, such as are desirable with shell construction to achieve the greatest economy.

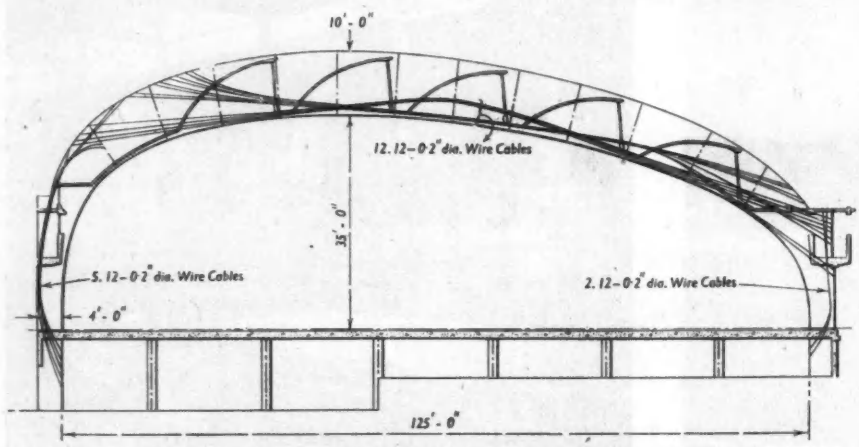


Fig. 1—Cross section of main production hall, showing precast sections of main arches, paths of the prestressing cables and the north-light shell roof

The total floor space available will be about 443,000 square feet, laid out to suit the productive flow of the printing processes, and comprising the main hall, which forms the north side of the works, the general printing hall and a smaller production hall south of it, and three to five-storey blocks on the south and east sides.

The Main Hall

A cross-section through the main hall is shown in Fig. 1 and Fig. 2 is reproduced from a recent progress photograph; it will be seen that the main arches span 125ft and carry north-light shell roofs between them. The first requirement for this hall was to cover a large space without internal supports. Rather detailed work will have to be carried on in the hall, and it is illuminated by natural lighting, so great care had to be taken in the design to make sure that glare was avoided. The sloping layout of the north lights, with frequent cross barriers provided by the main arches, was considered the best way of meeting this requirement, and at the same time providing sufficient intensity of illumination. The asymmetrical arched layout thus tentatively reached was favoured by the architect, who considered that in a building of such large dimensions, and particularly of such length, a flatter roof line would have been rather oppressive. The lack of any dust traps on the smooth surfaces of the shell roofs was also considered an advantage. The basic outline was thus fixed by these considerations and by the height of the "security galleries," as they are called, which run along each side of the hall; below them a substantially vertical column was obviously necessary. The asymmetrical slope of the roof could have been followed by a curve of the form $y^3=f(x)$, but this solution did not give the sharp curvature that was needed near the galleries, and so a curve in y^4 was eventually adopted, of the form: $y^3=b^4(1-x^2/a^2)(1-kx/b)$. The axes of the curve are defined by the values of a and b, and k is constant for the family of curves. The major axis is, in fact, 5ft below the floor level, shown in Fig. 1.

Substantial advantages were achieved by prestressing the main arches, thus modifying the line of resultant thrust so that tensile forces were avoided. The prestressing allowed the width of the arches to be reduced, and hence their own weight, which forms a large part of the dead load, was reduced as well. Fig. 1 shows the prestressing necessary in the legs of the arch, which acts against the dead load bending moments there, and the paths of the main cables across the lower part of the arch. Each cable path has one point of inflection only, thus reducing frictional losses (the cables are stressed from both ends) and avoiding other obstacles, such as the gutter pipes which run longitudinally through the arches in the valley beneath each north light. Each arch is 9in in thickness and, as may be observed, the number of prestressing cables is comparatively small for a span of 125ft compared with beam construction. The arches are built in pairs, with a gap of 3ft 6in between them, which accommodates the various services, and the pairs are spaced 36ft apart. The main hall thus comprises twenty-two sets of identical structures, each with two arches and shell roofs between them. The floor of the main hall is of reinforced concrete, sufficiently heavily reinforced to provide a tie between the legs of the arches.

It was decided to build the legs of the main arches in-situ, but to precast the remainder of the main arches in 5-ton sections and to cast the shell roofs in-situ.

By precasting the centre section of the arched beams and making units of about 5 tons weight a major part of the problem was solved, since the accurate shape of the arch could be ensured by casting every arch on an identical bed. As this bed would be laid out flat the concrete itself could be placed with a maximum control around accurately placed cable tubes, and a good surface finish obtained. Also the arches carry fixings for mechanical equipment installed in the roof spaces, and by this method the precise location of these fixings and other features could be ensured. A 5-ton derrick with 120ft jib was installed to handle the precast elements.

This method of erection depends on the use of a rather elaborate gantry, on which the precast arch sections are carried, and which incorporates the shell roof shutters. Fig. 3 shows the gantry in elevation; it can be moved along the length of the hall on rails and is articulated and can be jacked into each successive position for erection. The gantry carries and erects in one sequence of operations a complete set of roofing elements—that is a main arch at each end and the shell roofing in between (which together give a load of about 100 lb per square foot)—and so will be used twenty-two times to complete the work. Thus one sequence of operations corresponding to one position of the gantry completes a further 36ft length of the main hall. The time taken for this sequence

Fig. 2—Interior of main production hall. Construction is in progress in the background

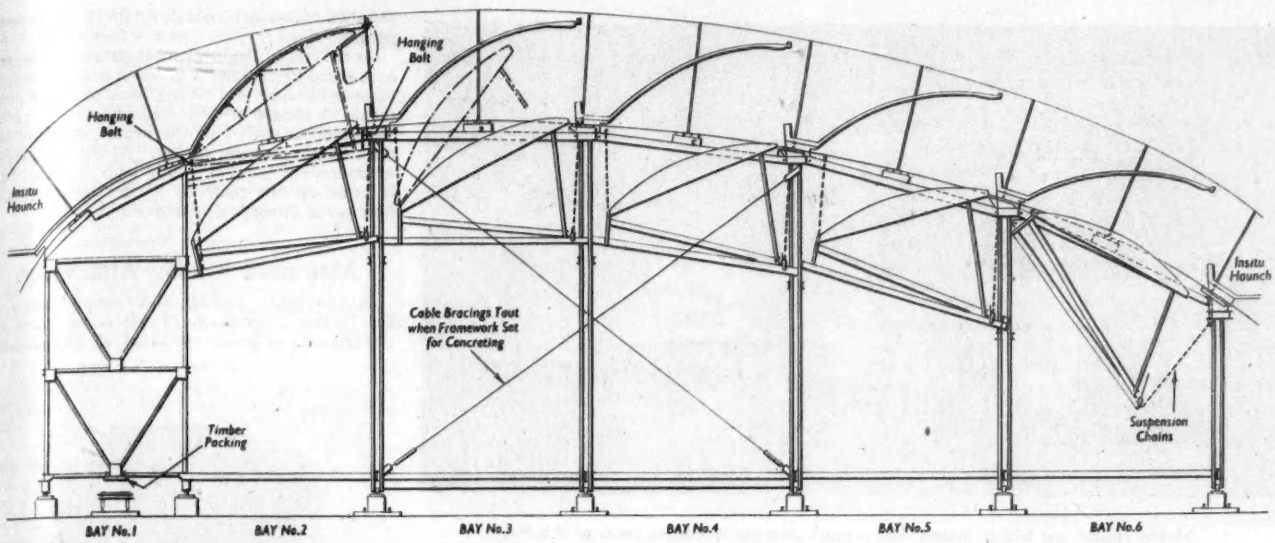


Fig. 3—Erection gantry for the main hall, showing main stanchions on jacks and packings supporting main ribs for concreting, but with the barrel shutters lowered. The travelling bogies are not indicated

therefore determines the progress of the work. The critical factor is the time which must be allowed before striking the shutters of the shells. The specifications did not fix a time limit but stipulated that a minimum concrete strength of 3000 lb per square inch had to be reached before these shutters could be moved. The contractor evolved a 1 : 1 : 2½ mix which consistently reached the specified strength in two and a half days, thus allowing the shutters to be struck on the third day. The main arches are tensioned—the Freyssinet system of prestressing is used—during and after the shutter-striking sequence, and finally the gantry is jacked down and moved in to the next bay. After some experience had been gained with its use, and the mix mentioned above perfected, it was found that a bay could be completed in one week, and this rate of progress is now being maintained.

Each of the winch-operated barrel shutters, which form the shell roofs, extends across the full width of the gantry, with telescopic make-up pieces next to the main arch ribs. When in position for concreting the shutters are carried by hanging bolts, and when lowered, they are carried on chains, as shown in Fig. 3. The hanging bolts are also indicated in Fig. 3, in bay No. 2, where one of the shutters is shown chain-dotted in the raised position. There are six hanging bolts for each shutter, one pair corresponding to each of the three transverse frames of the gantry.

When a section of roof has been completed and the concrete matured, the sequence of operations in striking and stressing is carried out according to a strict schedule. The small hinged shutter at the upper end of each barrel shutter is first lowered (as shown in bay No. 2) to allow the mullions of the north lights to be fixed. Half of the cables passing between the in-situ legs of the main arches and the precast centre section are then tensioned and at least four of the main cables in the centre section which join with the haunch cables are also tensioned; the "make-up" ends of the barrel shutters are slid back. Next the hanging bolts along the transverse centre frame of the gantry (i.e. one pair on each barrel shutter) are removed. Then the remaining four hanging bolts on each shutter are loosened to allow the shutter to free itself from the concrete with ¼in or 1in clearance. The weight of the shutters is then taken, successively, on the winches, and the hanging bolts removed.

The barrel shutters are lowered in the following order of bay numbers: 5, 4, 3, 2, and 6. Bay No. 1 is built into the gantry frame and is lowered when the main gantry stanchions are jacked down. The back edge of each shutter is first lowered, to the position shown chain dotted in bay No. 3, Fig. 3, and finally the front edge is lowered, until the shutter hangs completely on the chains. The barrel shutter in bay No. 6 is hinged at the back, and needs to be lowered only at the front edge.

When lowering the gantry, the transverse-centre-line jacks are first slackened and bay No. 1 is then lowered, followed by the end frame of bay No. 6. Prestressing of the two main arches is completed at this stage, and then the remaining frames are lowered onto the bogies, in the order 3–4, 5–6, 4–5 and 2–3.

The General Printing Hall

The general printing hall is also a shell-roofed structure, as shown by the drawing, Fig. 4. It was necessary to have expansion joints on each side of the hall, and so a complete break was made with the adjoining buildings by constructing a balanced cantilever structure. The hall consists of four free-standing bays, each made up of four cantilever beams spanned by a series of north light shell roofs, as shown in Fig. 4. Each shell is about 24ft long, so that each bay of three sets of shell roofs with cantilever supporting beams is 72ft long. By contrast with the main hall, the smaller dimensions in the printing hall led to a reversal of the erection method. The shells are precast and weigh about 5 tons each, and the cantilever beams are cast in situ with shutters in large sections which can be handled by the derrick. The beams are some 7ft deep and 9in and 6in thick. The prestressing system—the Gifford-Udall-CCL system is used—is completely exposed during construction, so that there is the minimum obstruction in the section of the beams. Prestressing is effected by a series of single wires assembled in twelve layers, one upon the other, in successive notches in the upper surface of the beam, each layer of wires being longer than the one below it. The anchorage of the wires consists of 1in thick metal plate buried in the concrete of the beams and projecting out in such a way that it can take a load, in the case of the 9in thick beams, of some 60,000 lb.

When the beams are cast and before they are stressed, the precast shells, which are constructed so that they are about 1in shorter than the space between the beams, are lifted by the derrick and placed between the beams. There are eight shells between each pair of beams. The space between the ends of each shell and the face of the beam, in which there is a ¼in recess, is then packed with mortar. When all the shells in the 72ft bay are in position and the joints packed, the whole roof is prestressed in a transverse direction, that is to say, along the shells and through the beams, with six prestressing wires to each shell. Then the beams are prestressed. This is done by working upwards from the shorter wires, layer by layer.

It was necessary to load the ends of each cantilever temporarily so that, as the stressing of the beams proceeded there was no over-stressing of the concrete at the top of the beam in compression. The prestressing wires on the top of the beam are concreted in, on completion, to protect them from the weather; this concrete, because it is not prestressed in the same way as the remainder of the beam, may crack, due to differential movement with consequent exposure and corrosion of the wires. It was decided, therefore, to load the beams in two stages—first, sufficiently to ensure that the concrete was not over-compressed during stressing and, second, to induce deflection in the cantilevers before surrounding the prestressing wires with concrete. When this concrete had matured the release of the loads would result in an upward movement of the cantilever and a consequent compression in the concrete on the top of the beam. The temporary loading is provided by a steel rod anchored by a stirrup at the underside of the ends of the cantilever, and joined to a short beam which itself is anchored to the heavy floor in such a way that loads up to about 7 tons can be quickly placed on the cantilever.

Extensive use has been made of precast and prestressed concrete techniques in the other parts of the new works at Debden. The small

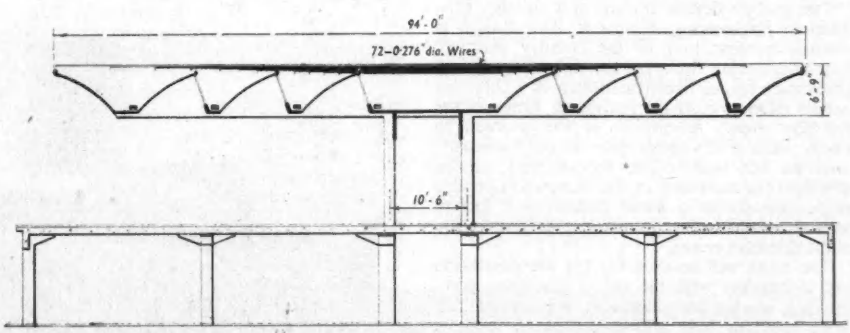


Fig. 4—Balanced cantilever beam and north-light shell construction of the general printing hall

Mobile cinema and lecture theatre, and demonstration and exhibition room of P.E.R.A.

production hall to which we referred is to consist of five bays of arched beam and shell construction, and the multi-storey bays incorporate precast elements which are repeated in different types of construction. A central concrete station equipped with two 1 cubic yard mixers is in use next to the casting yard. Pumps are used for the concrete work in the foundations. Practically the whole of the in-situ part of the concrete has been cast in steel formwork. In the case of the main machinery floors, which are from 12in to 15in thick and designed on the "mushroom" principle, which gives large areas of flat soffit surface, it was possible to fabricate forms on a framework so that they could travel in panels some 24ft long.

Construction of the new printing works at Debden was started in June, 1953. The architects are Messrs. Easton and Robertson and the consulting engineers for the structure are Messrs. Ove Arup and Partners; Sir Robert McAlpine and Sons, Ltd., is the contractor.

P.E.R.A. Mobile Demonstration Unit

THE mobile demonstration unit of the Production Engineering Research Association is starting its first tour of the country and will visit engineering firms by appointment. It will participate in the Scottish Industries Exhibition before making calls on individual firms in the Glasgow area. Afterwards it will proceed to Leeds, calling at various firms in the Newcastle area on the way. The mobile unit, shown arranged for travelling in the illustration on this page, consists of a small cinema and lecture theatre to seat twenty-four and a demonstration and exhibition room.

The room will be used for the demonstration and discussion, with the aid of machines, components, models and diagrams, of recommended techniques for tool grinding, drilling, tapping, turning, and grinding of various materials, blanking, deep drawing, impact extrusion, thread rolling, and other common production operations. These demonstrations and discussions will be mainly for the benefit of shop floor personnel in firms where the managements require the recommendations of P.E.R.A. to be adopted with the minimum delay, and with the co-operation of the foreman, charge hands and operators.

The exhibition dealing with the activities and services of P.E.R.A. will show the nature and range of P.E.R.A's research programme; the scope of the technical inquiry service; the monthly abstract and reprint service; details of refresher courses, training schemes, and other educational activities, organised at P.E.R.A. for personnel from industry; the facilities of the liaison service whereby engineers from P.E.R.A. visit member firms, when necessary, to consider production problems on the workshop floor, and assist in the application of P.E.R.A. research results and information services; and provide general information on the way in which the activities of P.E.R.A. are controlled by industry and supported by the Department of Scientific and Industrial Research.

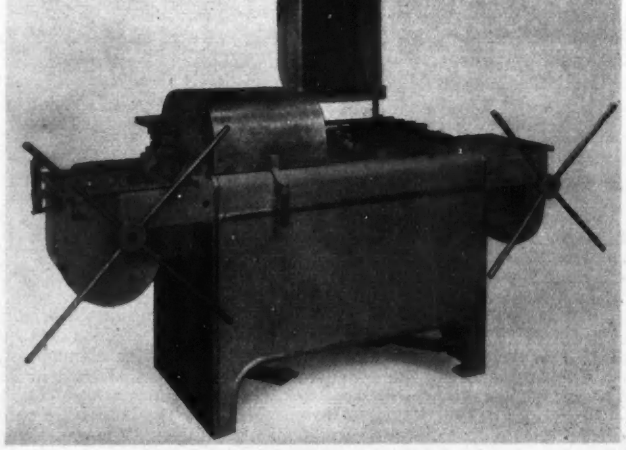
An extension provided with the unit is available for erection on site, to augment the space available for demonstrations of the use of special machines and other equipment.

The cost of equipping and operating the mobile unit throughout the country is being met by a special grant received through conditional aid and the Department of Scientific and Industrial Research.

Hand-Operated Two-Station Shell Moulding Machine

A SIMPLE, hand-operated, two-station, shell mould-making machine has been developed by Polygram Casting Company, Ltd., Power Road, London, W.4, for use by small foundries and for experimental work. This machine takes 14in by 12in mould plates and has a maximum draw of 4in. It is designed to produce up to sixty shells an hour and for operation by unskilled labour.

As can be seen in the photograph we reproduce herewith, the pattern plates are mounted on hinged plates at each end of the machine, and they are heated by gas flames from below the platform. In the sequence of operations the pattern plate is swung over on to its appropriate investment hopper, and in this movement its hinge pins ride free of their bearings. Latches automatically lock the pattern plate on the hopper, which, by means of long capstan handles, can then be swung upside down for the investment period.

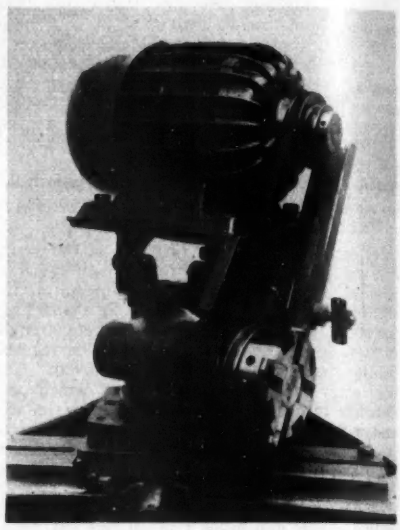


Two-station, hand-operated shell moulding machine for 14in by 12in pattern plates with 4in draw

At the end of the investment period the hopper is restored to its upright position and the pattern plate is released and swung back on to its platform. A hinged cover is then pulled down over the plate to seal it in the heated chamber for the necessary curing period. At the conclusion of curing the hood is swung back and the shell is lifted off the plate by ejector pins actuated by a pedal through a system of links.

Motorised Milling Attachment

A UNIVERSAL milling attachment known as the "UFK" Mark 4, of which we show an illustration, is being marketed in this country by Herbert Bennett, Ltd., 3a, Wood Street, London, E.C.2.



Milling attachment, set up with four carbide-tipped radial fly-cutters

It was originally developed for thread milling, keyway cutting and grooving, but is equally suitable for plain and end milling. The standard version has a spindle running in taper roller bearings, on which is mounted a cutter head of 118mm (4⅝in) diameter. This head is provided with four axial and four radial slots for the carbide-tipped fly-cutters which can be obtained from the makers in a variety of shapes. A 970 r.p.m., 1½ h.p. motor drives the spindle through a two-speed vee-belt drive (here shown with the guard removed). Alternatively, the pulleys can be replaced by three-step pulleys, thus giving a total of five speeds ranging from 270 to 1900 r.p.m. Cutting is assisted by the flywheel action of the head which weighs 8¾ lb.

If cutter bars for internal thread milling, grinding wheel arbors or drills are to be used the spindle can be supplied with a No. 3 Morse taper and with a separate flywheel.

The attachment, including motor, weighs 147½ lb and is designed for mounting on a lathe or milling machine. It can be swivelled through 360 deg. about a vertical axis and 15 deg. up or down about a horizontal axis. In addition the spindle axis may be tilted 15 deg. down and 100 deg. up in the vertical plane.

Steel Works Crane with Mechanically Operated Tongs

PARTICULARS have been received of a soaking pit charging crane for handling ingots weighing up to 16 tons, which has been built by Maschinenfabrik Deutschland A.G. of Dortmund, Germany, and has been fitted with ingot tongs incorporating means of mechanical adjustment. These tongs, which can be seen in the photographs we reproduce below, have a gripping range from 0mm to 1600mm. The opening of the tong arms can be adjusted directly by the crane driver's controls in the cabin, to facilitate the handling of square or rectangular ingots of different sizes and weights without loss of time.

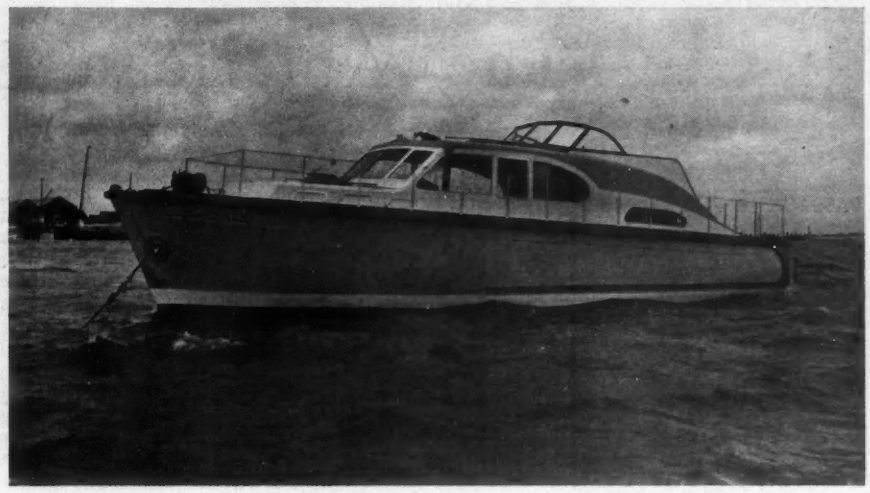
The crane is of conventional design with a frame extending downwards from its crab to form a guide and support structure for the tong column assembly. From the driver's cabin on the front of this structure the crane operator has an unobstructed view of the tongs without moving from his controls. The normal crane motions are controlled through small levers conveniently grouped in front of the driver's seat. The cabin has insulated double walls and floor and an air conditioning plant in the roof.

The tong hoisting gear mounted on the main crab frame is connected to the upper supporting cross member of the tong column. This cross member runs between guide rails in the frame and in it the column is rotatably mounted in heavy bearings. A second guide bearing for the column is mounted in a fixed cross member at the foot of the frame. The tong column can be rotated in each direction on its vertical axis through gearing on the crab frame.

The two cast steel legs of the tongs are supported on a massive head at the foot of the column and they are opened and closed by a system of links pivoted to a heavy central shaft passing through the column. Power for raising and lowering the shaft to open and close the tong legs through the links is provided by an electric motor. This motor is mounted on the upper cross member of the column assembly and its drive is transmitted through a hydraulic clutch and worm gearing. By mounting this drive at the top of the column it is kept well away from the effects of the heat radiated when handling the hot ingots. The upper ends of the tong arms are fitted with rollers which run in inclined ways in the head; through a spring gear the arms are returned at the highest point of these ways when no load is being supported.

When it is required to lift an ingot the gap between the arms is closed by the motor-operated system of links until a light preset holding pressure is exerted by the jaws on the ingot. At this stage the hydraulic clutch in the drive comes into effect and no further mechanical load is applied. As the tong lifting gear is then engaged the grip of the tong jaws is increased in proportion to the weight of the ingot as the rollers on the upper part of the arms are drawn down their inclined ways.

When the ingot is deposited the arm closing gear is operated in reverse to draw the tong jaws clear of the ingot by a small amount. The spring gear then comes into effect to draw the arms back up their inclined ways to give the maximum jaw opening.



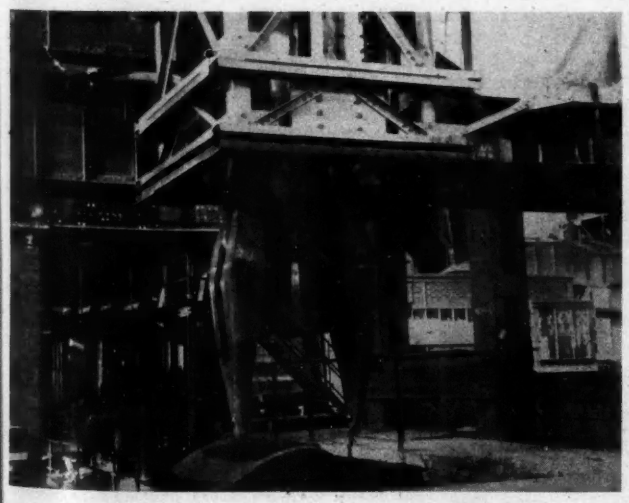
Twin-screw cruiser with hull of polyester resin reinforced with glass fibres

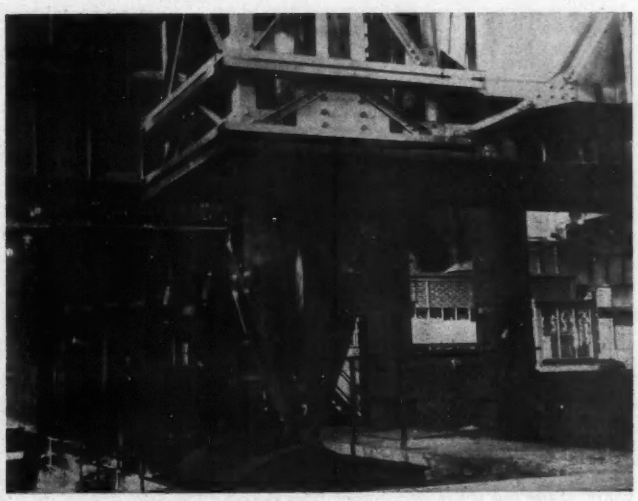
Plastic Small Craft

EARLIER this year, in an article which appeared in our issue of April 9th, we referred to plastic boat construction using a material named "Deborine," developed by Halmatic, Ltd., Portsmouth. This is a polyester resin reinforced with glass fibres, treated to harden it and rendered fireproof by the addition of certain chemicals, including antimony oxide. To the technical data given in the previous article can be added the results of a tup test designed to reproduce the conditions of a vessel striking a protruding object when coming alongside. A steel hemisphere 3in in diameter was dropped on to a panel between frames, and the laminated plastic offered twice as much resistance as wood to minor damage and between 25 and 50 per cent more resistance to being pierced. The returns from the bend-break test showed that a plastic panel complete with frames was more than three times as strong as a comparative wooden panel.

Among the craft the company has completed is a round bilge launch which has a length overall of 26ft 6in, a water-line length of 25ft, a breadth of 8ft, and a draught aft of 2ft 3in. The hull, which weighs 630 lb, has a skin thickness of ¼in, consisting of a layer of resin, a layer of glass scrim and resin, and two layers of 2 oz glass mat and resin. The transverse frames are spaced 6in apart and are formed of two-layer glass rovings tape moulded in hollow box sections measuring 1in by ½in. Also completed is a round bilge twin-screw fast cruiser, as illustrated: length overall, 45ft 10in; water-line length, 43ft; beam, 12ft. This vessel, which is arranged to sleep six, has a spacious flying bridge, protected by a screen, with a steering position arranged forward to port. A stairway, covered by a sliding hatch, provides access to a roomy deck saloon fitted with a settee, which can be converted to a double berth, a dining table, sideboard, writing desk, and a lower conning position. From the saloon a ladder leads forward and down to a well-equipped galley and a toilet compartment, at the forward end of which a door gives access to a two-berth cabin for the crew. The fore peak forms the chain locker.

At the aft end of the deck saloon there is a starboard stairway down to a lobby leading to a double-berth stateroom, complete with dressing table and chest of drawers, and to a separate toilet compartment. The engine-room is located under the floor of the deck saloon and the space is occupied by two Mark 6L.W. Gardner four-stroke diesel engines, each of which has six cylinders in line and develops 72 b.h.p. at 1200 r.p.m. and drives through a "Silentbloc" coupling. Push-button electric hydraulic reverse gear is fitted and steering is effected by twin-spade rudders. The steering mechanism is housed in the large aft peak compartment, accessible from a hatch in the deck over, with two fresh-water tanks and two fuel tanks each of 115 gallons capacity.





Soaking pit crane fitted with mechanically operated tongs for handling ingots weighing up to 16 tons, and having a gripping range from 0mm to 1600mm. Tongs shown in open and closed positions

The American Scene

(By Our American Editor)

PASSAGE OF THE ATOMIC ENERGY BILL

By a vote of fifty-seven to twenty-eight, the U.S. Senate on July 27th passed the bitterly contested Atomic Energy Bill, thus ending a marathon debate known in American parliamentary language as a "filibuster." At issue during the thirteen days and nights of debate was an Administration measure to revise the Atomic Energy Act of 1946 and involving two important agencies of the U.S. Government—the Tennessee Valley Authority and the Atomic Energy Commission. It is felt that the controversial atomic power issue will not fade in spite of the Government's victory in obtaining passage of the Bill, which now will allow private power interests to enter the atomic energy field. As part and parcel of the raging public-versus-private power fight, it is certain to be carried into the Congressional election campaign this autumn. This alone is likely to pose a much greater test of the Eisenhower Administration's power policy than the long hours of debate which created chaos in the legislative programme and forced a delayed adjournment of Congress.

Ever since the present Administration made its first move, soon after taking office in 1953, on a power "partnership" with State and local governments and private enterprise, the cry of "give-away" has been heard in Congress. But that howl is as nothing compared with that now being made over the first major revisions of the Atomic Energy Act of 1946. The issue concerning the T.V.A. arose as a result of a recent order by President Eisenhower directing the Atomic Energy Commission to negotiate a contract with two private utility companies to build a steam power plant at West Memphis, Arkansas, which would feed 600MW into the T.V.A. grid, to replace power which the Authority is currently providing for the large gaseous diffusion works of the A.E.C. at Paducah, Kentucky. The Government's timing in disclosing this order by the President was an unexpected windfall for the Democrats. It became a perfect weapon for those Democrats rallying to keep in force the Roosevelt-Truman power policy of the past two decades. The public-power advocates argued that as a natural resource the atom should be protected against the greedy hands they contend are reaching out to seize it to build new electric power monopolies. This view encompasses the belief that the public investment of 12,000 million dollars in the development of atomic weapons should not be tossed into the outstretched hands of the private utilities. Specifically, the public-power advocates see the Bill as preventing rural electric co-operatives, municipalities and other public bodies from gaining the benefit of atomic power, and as heralding a return to the days of the "power trusts." This would be accomplished, they contend, through provisions relating to patents for atomic reactors built to utilise atomic energy for electric power generation. There is some disagreement among scientists as to when in the future atomic electric power will become competitive with, and cheaper than, conventional electric power. Some say five years, some ten years or longer. The present Atomic Bill provides that for five years all patents relating to atomic discoveries shall be subject to licensing to all comers as an anti-monopoly endeavour. But what happens, the Democrats ask, if atomic power becomes a reality in five years? Their view is that almost overnight atomic energy will have slipped out of the public's hands into those of the private utilities who then can proceed to do with it what they will—even hold back its development until they can work out their investment in existing facilities. To meet this possibility, they want compulsory licensing for a longer period or until there is no threat of a patent monopoly. The Republicans just as fiercely deny such allegations. The chairman of the Joint Congressional Committee on Atomic Energy, a Republican, succeeded in writing into the Atomic Bill in the House a removal of the patent licensing provisions. He challenged the constitutionality of the provision, saying that it was "wholly foreign and hostile to American tradition and practice, and the system of free private enterprise." This sums up the view of those who believe that the quicker the war-born Government monopoly in atomic patents is returned to the normal American patent practice—exclusive rights for seventeen years—the quicker private enterprise will move into the new field to do with the atom what it has done with the motor-car and other products of the American industrial machine. This, they argue, is the path to keep atomic energy from moving down the "road to socialism."

The supporters of the Atomic Energy Bill have acknowledged that the danger of restrictive patent practices is present, though not imminent in the immediate future, when few firms will be involved in the effort of both Government and industry to make atomic power a reality through "teamwork" in research and development programmes. The believers in the Eisenhower policy of "power partnership" argue that the licensing provisions of the Bill cannot possibly favour private utilities over public bodies because the private groups will be subjected to the same regulation, either Federal or State. What started out as a handful of Senators battling to "save" the T.V.A. thus grew into a rather cohesive group of strange bed-fellows. Liberal Democrats gained support from some who probably never had voted against a private utility in their careers. The Administration used little persuasion in the power fight. Its method was to assert the need for putting across the major portions of the President's legislative programme. It claims that the Democrats seized upon the Atomic Energy Bill as a weapon to slow up the programme during an election year. It appeared that the Republican Senators who rallied behind Senator William F. Knowland, the majority leader, simply did so in an effort to accelerate the programme and to adjourn. There can be no doubt, however, that the whole tone and climate of the eighty-third Congress has been altered sharply in the long fight over public versus private power. This issue, emerging so suddenly and so bitterly toward the end of a Congress nineteen months in session, may come more nearly to dominate its record than any other single factor in terms of partisan meaning for the November Congressional elections. To quote the words of a high official of the Democratic National Committee addressing the embattled pro-public power Democrats: "At last you have given us the head for the spear."

Sodium-Graphite Experimental Reactor

The U.S. Atomic Energy Commission has announced that the first sodium-graphite reactor to be built in the United States will be developed and constructed in a project sponsored jointly by the Commission and North American Aviation, Incorporated. The reactor will be an experimental model of a full-scale power reactor which is already in the preliminary design stage. It will use metallic fuel elements of either slightly enriched uranium or a combination of thorium and uranium 233. It is expected to be in operation by 1957.

North American Aviation, which has been the principal contractor of the A.E.C. in the development of the sodium-graphite reactor, has agreed to assume up to 2,500,000 dollars of the expected total cost of 10,000,000 dollars of the model and to supply the reactor site, at no cost to the Government, near the company's field test laboratory in the Santa Susana Mountains, north of Los Angeles, California. The company also will operate the reactor plant experimentally for approximately two years under terms of a recently signed contract with the A.E.C. The present project will resemble the full-scale plant designed by the company, but will generate only about 20MW of heat and no electricity.

In addition to its sodium-graphite development work, North American Aviation has built two low-power "water boiler" homogeneous reactors for the A.E.C., one at the company's Downey Works and one at the research facility of the A.E.C. at Livermore, California. Graphite has been widely used as a moderator in United States reactors since the first experimental pile at Chicago, and a mixture of sodium with potassium is the coolant material in the experimental breeder reactor at the National Reactor Testing Station in Idaho, which was the first pile to demonstrate experimentally that electricity can be produced from nuclear energy.

High Strength Titanium Alloy

The Armour Research Foundation, of Chicago, Illinois, working under contract to the Watertown Arsenal, U.S. Army, has developed a tougher, stronger titanium alloy with properties comparable to the high-strength steels used in weapons and armour plate construction. Tests conducted by the U.S. Army at the Watertown Materials Testing Laboratory indicate that the new titanium-based material overcomes many of the disadvantages, such as lack of ductility at high strength, which have limited the use of titanium in many ordnance applications. Like other titanium-based alloys, the new 6 per cent aluminium, 4 per cent vanadium material is 45 per cent lighter than steel and has good corrosion resistance. An unusual ductility at high strength levels differentiates the new material from present alloys. When heat-treated to a tensile strength of 190,000 lb per square inch it maintains a ductility of 14 per cent elongation and 45 per cent reduction in area. The notch toughness at this strength also remains unusually high, as indicated by Charpy impact values of 11ft-lb at −40 deg. Fah. For even higher toughness requirements a different heat-treatment gives a 32ft-lb V-notch Charpy impact energy at a tensile strength of 147,000 lb per square inch with 18 per cent elongation and 56 per cent reduction in area.

The properties of the new alloy compare very well with the martensitic stainless steels, and some of the low-alloy high-strength steels, such as S.A.E. 6150, 8640 and 9440 have properties, nearly identical to the titanium alloy. However, the titanium alloy enjoys a considerable strength/weight advantage over these materials.

Induction Welding of Light-Wall Non-ferrous Tubing

A TUBE mill which was recently installed at the works of the Bridgeport Brass Company, is the first machine to go into commercial operation in the United States producing light-wall non-ferrous tubing by the continuous high-speed cold forming and induction welding method. The mill was designed and built by the Yoder Company, of Cleveland, Ohio, and is based in many respects on the general design of the company's electric resistance weld mills used in the manufacture of ferrous tubing. The induction welding method employed facilitates the production of non-ferrous tubing ranging from ¾in to 4in in diameter and from 0·025in to 0·134in in wall thickness at speeds of 40ft to 120ft per minute, depending upon the wall thickness and the tube diameter, as well as on the metal being handled. This is claimed to be from ten to thirty times faster than previously known methods of welding non-ferrous tubing and compares favourably with the speeds of up to 150ft per minute which are used in the electric resistance welding of steel tubing.

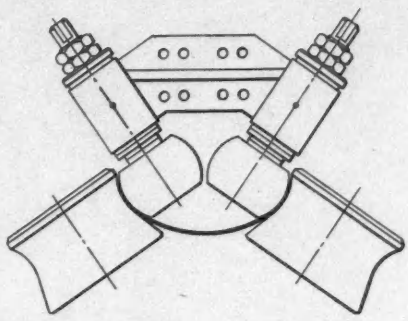
The mechanism of induction welding employed causes the high-frequency current to be delivered to a short water-cooled inductor coil through which the cold-formed tube passes without contact. The induced current travels circumferentially around the tube surface in the region of the inductor, then flows along the seam edges of the unwelded tube to a point of convergence, which is substantially beyond the field of induction and close to the centre line of a set of rolls which forces the all-but-molten edges together. As the current approaches the abutting edges the "skin effect" as well as the "proximity effect" confines it to a shallow layer on the surface. Practically all the current passes between the edges at the point where the weld is being made. It has been found that little or no shunting current passes across the seam beyond this point.

The factors of skin effect, proximity effect, and reactance are predominant at the frequency of 450kc/s now employed, thus confining the heat-affected weld zones to an extremely narrow path. Tests have shown that the weld zones in tubing made from different grades of aluminium, nickel and other non-ferrous metals are uniformly narrow, with the grain structures remaining virtually undisturbed by the heat. The exceptionally short time at temperature involved in the induction welding method enables one to touch the weld with bare hands less than one second after it is made. It is of interest to note that a microscopic examination of tubing welded from 18–8 stainless steel strip also indicated a uniform grain structure in the weld zone; no carbide precipitation could be seen in areas adjacent to the weld. The joint itself was solid and free from gas holes, porosity, oxides and stress cracks. No evidence was detected of preferential corrosion in samples tested in nitric acid, and tensile tests showed the metal in the weld zone to be 15 per cent stronger than the original strip.

The weldable metals include almost the entire range of aluminium alloys which are available in coiled strip form; certain magnesium alloys; a wide range of brasses and other copper alloys; nickel and its alloys; austenitic and ferritic stainless steels and the lighter gauges of carbon steels. Partly because of its high electrical conductivity and the absence of a plastic welding range, only limited success has been obtained in the welding of commercially pure copper.

The new mill was designed to facilitate the production of tubing with a minimum practical wall thickness of 0·025in. It was expected that the major obstacle in forming such light gauges would be the tendency of the edges to wrinkle and buckle. Edge buckling is considered to be a column failure at the edges of the tube blank, caused by residual compression adjacent to the edges stretched longitudinally in the early forming passes. Due to the nature of the phenomenon, failures, for a given size and gauge of tube, are aggravated by an increase in yield strength and a decrease in the modulus of elasticity of the material. The forming problem was complicated particularly by the need for an adaptable roll set-up to handle different metals with a yield point ranging from 4000 lb to 75,000 lb per square inch and a modulus of elasticity ranging from 10,000,000 lb to 30,000,000 lb per square inch.

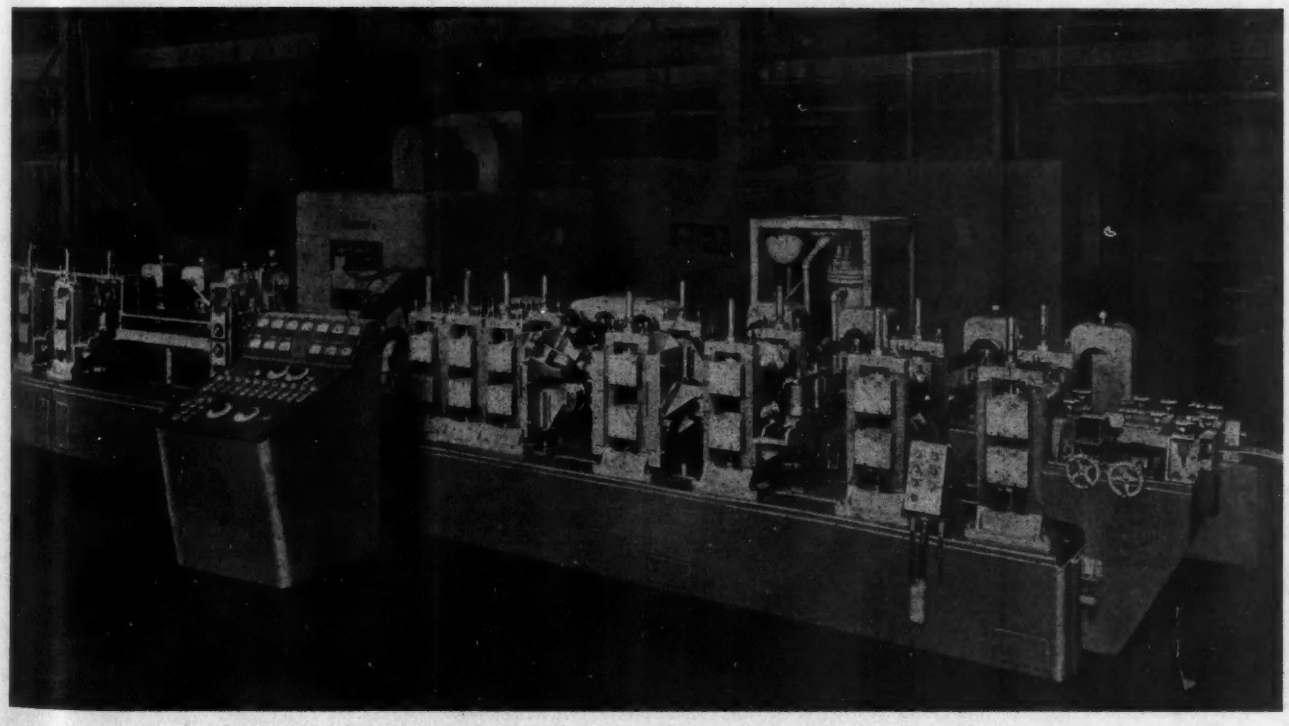
Steel tube mills usually contain a series of six or more pairs of driven forming rolls, all revolving in a vertical plane and thus exerting pressure from both top and bottom. Between each of the first three or four mill housings, in which the flat strip is formed progressively into an open tube with a gap at the top, idler rolls usually are mounted



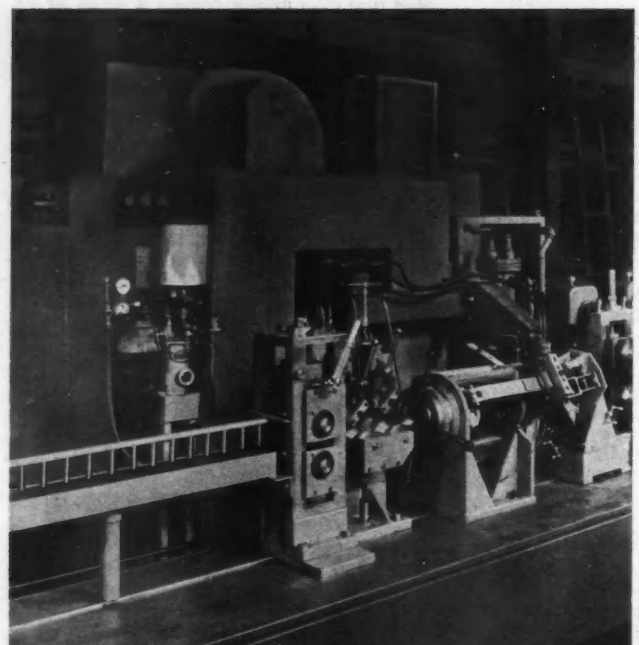
Four-roll idler cluster method of edge forming

on vertical spindles to provide side pressure and to facilitate the entry of the strip into succeeding roll stands. These idler or side rolls do no real work on the partially formed tube. However, in the now developed process, at least one pair of idler rolls has the important function of edge forming. This operation aims to overcome the inherently greater difficulty of bending the strip at its edges than at the centre. In the new mill the control of edge stretch on thin gauges is facilitated by the use of: (*a*) adjustable lower as well as upper roll spindles; (*b*) generous roll diameters; (*c*) two additional triple-roll idler clusters for the critical vertical transition from the final breakdown pass to the first finishing pass; (*d*) a new method of edge forming; and (*e*) correct spacing between the successive roll passes.

In forming the common gauges of steel strip into tubular shape the advantages and the disadvantages of adjustable lower roll spindles are about balanced. However, in the production of non-ferrous tubing, adjustable lower spindles appear essential because of the physical properties of the metals and the high ratio of wall thickness to diameter involved. The accompanying diagram shows the four-roll idler cluster method of edge forming used in the new mill. It



Four-inch tube forming and welding mill at the Bridgeport Brass Company



Welding unit of tube mill

uses single-radius forming in all the breakdown passes and does the edge forming in a cluster comprising two pairs of idler rolls after the strip had been first bent longitudinally to a shallow U shape in the first two or three driven passes. The four-roll cluster operates at an angle and, unlike conventional idler rolls, does actual forming by applying pressure from both sides of the metal at the edges. The design is readily adjustable to a greater or smaller arc across the strip width, and accommodates a wide range of gauges with one single set of small rolls.

The forming section of the tube mill includes an entry table equipped with felt wipers, pull-over-pull-under rollers, tungsten carbide-faced side guides and a pair of adjustable edge trim cutter holders used to ensure exact stock width and clean, smooth edges. The first driven roll stand has flat feed rolls for pulling the stock through the edge trimmer. This is followed by three driven roll stands carrying breakdown rolls, which, in combination with idler rolls between and beyond the stands, completely form the strip to approximately tubular shape, with a gap left between the edges at the top. The first set of idler rolls is of conventional design. The second set, between the second and third breakdown rolls, is the diagonally mounted arrangement shown in the above engraving. Two pairs of triple-roll idler clusters are set between the third driven roll stand and the first finish pass. The three finish pass roll stands are closely coupled in a single housing.

Welding Section of Mill

The welder unit of the mill comprises a seam guide and spreader blade with a three-roll cluster of idler rolls and the inductor coil which induces welding current in the tube blank. The squeeze rolls in this mill are of a new design and include a holder for the three-roll cluster, each roll being adjustable to obtain correct pressure through the operation of a star wheel. Pressure is measured by a strain gauge situated on one of the roll mounting arms. An outside welding burr or flash trimmer, as well as a set of ironing rolls, are of standard design. Where the tube size permits, a mandrel can be used to trim off the flash inside the tube. A short cooling section is provided between the welding unit and the sizing mill. The latter unit comprises three driven and three idler roll stands, with a universal straightener at the exit end. A flying cut-off saw has been incorporated in the mill installed at Bridgeport. The mill drive includes a variable-voltage generator which is excited by a magnetic amplifier. The latter unit compares the forming mill tachometer voltage with a reference voltage, and thus holds the mill speed within 0·5 per cent of the preset value. A 50kW welding oscillator takes power for its plate rectifier from a 100kVA three-phase alternator set, designed to eliminate the effects of supply line voltage variations. The alternator is also excited by a magnetic amplifier, which maintains the plate voltage of the oscillator at any level that may be desired.

The illustration reproduced herewith shows several samples of non-ferrous tubing produced on the induction welding mill. The samples had been subjected to physical tests and showed no weld failures whatsoever. In the central foreground is a piece of pure nickel tubing; grouped around it, from left to right, are tubes made respectively from a 70 Cu-30Zn brass, a 2·5Mg-0·25 Cr aluminium alloy corresponding to the American 52S–H32 specification, a low-carbon steel, and a 1·4 Mg aluminium alloy corresponding to the American 50S–H32 specification.

In addition to producing light-wall tubing for conventional uses, the new process is believed to be particularly well adapted for making aluminium cable sheathing. In this respect the process has the additional advantage that the cable and the strip can be simultaneously fed into the mill, and the tube continuously formed around the cable at high speed while passing through the forming machine. After passing through the welder the tube becomes a sheath which is slightly reduced in diameter by passing through the sizing mill, all without the application of heat. In addition to affording a weld strength equal to, or exceeding that of the bare metal, the continuous feeding, at speeds up to 120ft per minute, offers substantial cost savings compared to other methods of cable sheathing. It has been found that the heating of the tube incidental to passing through the welder is so slight that no damage will result to paper-wrapped cable, yet a permanent water- and gas-tight weld is obtained.

Samples of induction welded non-ferrous tubing

Waterways Experiment Station of the Corps of Engineers

The Waterways Experiment Station of the U.S. Army Corps of Engineers at Vicksburg, Mississippi, recently had the twenty-fifth anniversay of its founding. Born of the disastrous Mississippi River flood of 1927, the Waterways Experiment Station has grown in twenty-five years from a small hydraulic laboratory devoted to studies connected with the flood control plan for the Lower Mississippi Valley into what General Sturgis, the Chief of Engineers, U.S. Army, recently called " the principal research and experimental facility of the Corps of Engineers in the field of hydraulics, soils mechanics and concrete engineering." The Station's Hydraulics Division has conducted hundreds of model studies covering almost every conceivable kind of river, harbour and flood control problem in the past, including several for foreign governments.

The Station has what is believed to be the largest hydraulic model in the world, a model of the entire Mississippi basin covering over 200 acres. Its practicality was most rewardingly demonstrated during the 1952 flood in the Missouri Valley. At that time the Kansas City and Omaha Districts of the Corps telephoned rainfall and run-off data to the Experiment Station, whose engineers, working day and night to simulate flood conditions in the model, were able to predict, with extraordinary accuracy a week in advance, the time and occurrence of the flood crest along the endangered dykes, which part of the valley would be flooded, and which parts would either remain dry or could be protected. This advance information enabled field engineers to concentrate their flood fighting at the critical points. The accuracy of the forecasts made possible by the model operation was found to be a major factor in preventing an additional 65,000,000 dollars damage to the Omaha-Iowa City area.

Engineers of the Station's Soils Division have conducted field and laboratory tests of soils at the sites of many of the large earth dams in the Mississippi Valley and have designed these flood control works. They have also conducted foundation investigations for concrete dams and outlet structures in the valley and have provided the slope design for the dam excavations. When the Corps of Engineers took over airfield construction early in the last war it found that there were no standards for the design of flexible pavement runways. A flexible pavement laboratory was added to the Soils Division in 1943 to develop design criteria for these pavements. The results of the Vicksburg flexible pavement studies were later used in constructing airfields throughout the world.

Passenger Belt Conveyor in New Jersey

The Hudson and Manhattan Railroad has put into operation at its Erie tube station in Jersey City, New Jersey, what is said to be the world's first passenger belt conveyor. Known as the " Speedwalk," the conveyor transports passengers for a distance of 227ft up an inclined ramp leading to the Erie railway terminal. The " Speedwalk " was designed by the Goodyear Tire and Rubber Company, of Akron, Ohio, and the Stephens-Adamson Manufacturing Company, of Aurora, Illinois, and was installed by the staff of the Hudson and Manhattan Railroad. The conveyor belt is ⅜in thick and 460ft long. Operating at a speed of 120ft per minute, the conveyor now carries passengers who walk along its moving surface to the end of the ramp in thirty-five seconds, compared with a previous normal upgrade walking time of fifty-five seconds. It negotiates a 10 per cent gradient for the first 137ft. It can accommodate 10,800 persons an hour, although only about 9000 passengers now use the station daily.

A 20 h.p. electric motor drives the endless belt, which rides on a bed of closely spaced idle steel rollers. The rubber and fabric belt is 5ft 6in wide and weighs 11,000 lb and has moving handrails. The system, which is reversible, is operated upgrade and between the hours of 7 a.m. and 7 p.m. only for the present.

Industrial and Labour Notes

T.U.C. General Council's Report

Next week the eighty-sixth annual Trades Union Congress is to be held at Brighton, under the chairmanship of Mr. Jack Tanner. The general council's report, which is to be discussed at the Congress, was issued a few days ago ; it records in some detail the principal activities of the T.U.C. during the past twelve months.

One section of the report is entitled " Industrial Policy and Organisation." It states that the general council is able to report continued progress in promoting higher standards of productive efficiency in industry, so vitally necessary for the maintenance of the existing standard of living and to improve the effectiveness of the part trade unions are playing in achieving that efficiency. The report adds that the general council has continued to develop its technical training facilities so that trade union officers may be helped to assess the trade union implications of modern production and management techniques in safeguarding and advancing the workshop interests of their members. It is also stated in this section of the report that the general council has continued throughout the year to pay close attention to developments in work study. The report says that " this is a technique increasingly employed by management to secure the more effective use of existing industrial resources as distinct from the long-term planning aspects of research and capital investment." Work study, the general council comments, successfully applied in agreement with individual unions, has produced comparatively rapidly some significant increases in productivity and, following negotiations, has resulted in improved earnings and better conditions for workers. Proper consultation, it is urged, is an essential prerequisite of work study, " which must not in any way limit opportunities for collective bargaining."

The section of the general council's report entitled " Research and Economics " suggests that the prospects of a continuing expansion of world trade are clouded by the recession which developed in the U.S.A. in the latter part of 1953. The report observes that " fierce competition is now developing in export markets " and emphasises that the nation's ability to maintain full employment will depend more and more on the productive efficiency of the economy. The report goes on to say that, internally the most obvious and welcome development has been the resurgence of industrial production which in 1953 was about 6 per cent higher than in 1952. In the first five months of this year production was about 6 per cent higher than in the corresponding period of 1953. But, the report adds, production of coal fell slightly in 1953, because of extra holidays, and, although the industry has set itself a target of a 2½ per cent increase, production so far this year has been running below last year's level while consumption has continued to rise. This trend, the general council remarks, " is bound to be a matter of general concern in view of the dependence of production and employment on adequate fuel supplies."

Changes in Wage Rates

Changes in wage rates, which were reported to the Ministry of Labour as becoming effective during July, resulted in an aggregate increase of about £162,000 in the weekly full-time wages of 823,000 workpeople. The changes also led to a decrease, aggregating about £18,000, in the weekly wages of 246,000 workpeople.

The decreases for the most part occurred in the iron and steel industry where there are sliding-scale arrangements based on the index of retail prices. Among those who received wage increases were the operating staff of British Road Services and craftsmen and labourers employed in building and civil engineering construction in Northern Ireland. In the first seven months of this year, changes in wage rates resulted in an increase of £2,413,000 in the weekly wages of 7,720,000 workpeople, compared with an increase of £1,338,000 for 5,020,000 workpeople in the corresponding period of last year. At the end of July the index of rates of wages (June, 1947=100) stood at 142 for all workers, having risen four points since the beginning of the year.

Trade Disputes

The Ministry of Labour has stated that during the month of July there were ninety-one stoppages of work in the United Kingdom, as a result of industrial disputes. These stoppages caused a loss of 78,000 working days and involved, directly and indirectly, 15,700 workers. In the comparable month of last year there were 102 stoppages of work through disputes, the number of workpeople involved being 15,100 and the number of working days lost 32,000. In the first seven months of this year, 768,000 working days were lost by 216,500 people in the 1119 stoppages through disputes which were reported to the Ministry. The situation was thus less satisfactory than in the comparable period of last year when 679,000 working days were lost by 155,500 people in the 934 stoppages which were reported.

During July, the majority of the stoppages were in the coal mining industry, although all of them were of comparatively short duration. The other stoppages included the strike of coke oven workers in South Wales which lasted for fifteen days, and arose from dissatisfaction over a wage claim. Although only 230 men were directly involved, the strike indirectly affected about 3530 people employed in the steel works. The Ministry of Labour says that ten of the work stoppages which began in July arose from demands for wage increases, and thirty-two were concerned with other wage questions. There were nine stoppages of work over matters respecting the employment of particular classes or persons, and twenty-eight stoppages over other questions respecting working arrangements. One stoppage, directly involving 100 workers, was in support of workers involved in another dispute.

Accident Prevention in Steel Works

The operational research section of the British Iron and Steel Research Association is engaged in an investigation to discover just how effective accident prevention methods—apart from the physical safeguarding of machinery and plant—can be. The investigation is being made at a single iron and steel works, where accidents over a period of years are being studied. At this particular works, 831 people started employment in 1947. B.I.S.R.A. says that accident rates were analysed in relation to the successive six month periods that each worker remained with the firm. Of the 831, about 45 per cent left during their first year, and about 35 per cent remained during a four-year period which was studied. When the incidence of accident was measured in relation to the period during which workers were exposed to risk of accident, it was found that the accident rate of those who left during the four-year period was one-and-a-half times greater than that of the " stayers." Moreover, by the end of four years' service, the liability of employees to sustain accidents was, on the average, about half what it was at entry. With these facts established, it is suggested that any means of speeding up the learning process that obviously takes place would be a major contribution to accident prevention.

It is stated by B.I.S.R.A. that the rate of learning can be measured by comparing what happened to the " stayers " during the first and second halves of the four-year period. Four classes of accidents accounted for three-quarters of all the accidents. They were accidents caused by something the worker was handling, by something he stepped on or hit, by something that fell on him, or by a fall by the worker himself. The number of accidents from all these causes except one was much less during the second two years than the first two. The exception was the " handling objects " class, which doubled from nine to eighteen for the 289 stayers. Another factor that has emerged so far from this investigation is that the age of entry into employment has little or no effect on propensity to accident. Furthermore, entrants from other steel works are no better than the entrants from elsewhere in their accident rate and are below average in their rate of learning to avoid accidents. According to B.I.S.R.A., entrants from the Services have a better than average accident rate from the start and also learn more quickly.

Advisory Committee on the Census of Production

The Board of Trade has announced the appointment of the statutory advisory committee on the Census of Production. Its function is to advise on the preparation of forms and instructions for the census to be taken in 1956 in respect of the year 1955. Mr. J. Stafford is the chairman of the committee and the secretary is Miss J. M. Milne of the Board of Trade (statistics division), Lacon House, W.C.1.

The report of the general council of the Trades Union Congress, to which reference has been made in a preceding note, includes some observations about the census of production. These observations are part of the evidence which the general council submitted last year to a committee then set up by the Board of Trade to advise and make representations about future policy on the taking of censuses of production and distribution. The T.U.C. view, as expressed by its general council, is that there is " no justification for changing the policy of taking an annual census of production whatever variations may be made from time to time in the scope of the census." It is felt, however, that there should be made available more precise information about productivity changes in different industries, about industries' capital investment plans, and up-to-date information about the inter-connection of firms. The T.U.C. also says that there is much criticism among its affiliated unions about the time at present taken to publish the census results. It feels that consideration should be given to improvements in the time taken to publish results, including if necessary the appointment of additional staff in the census office. But the T.U.C. does not suggest that " there should be any reduction in the standards of accuracy or any decrease in the amount of detail published in the census reports."

Industrial Production

The central statistical office of the Treasury has stated that the index number of industrial production (1948=100) was 127 for all industries in the United Kingdom in the month of June. This was nine points higher than in June last year, which month, it will be recalled, included the Coronation holiday. This year, industrial production in June was affected by the Whitsun holiday. Taking the manufacturing industries only, the index number for June was 131 and that for mining and quarrying was 107. The Treasury says that, on the basis of information which it has so far received, the index number for all industries in July is expected to be 115 or 116. Last year the July index number was 110.

Industrial production in Sweden in the first half of this year was 5 per cent higher than in the corresponding period of 1953, according to statistics published recently by the Federation of Swedish Industries. The Federation says that the index figure for June (1935=100) was 226, compared with 214 for June, 1953. In the first six months of this year, the Federation reports, production in the Swedish pulp and paper industry was 17 per cent higher than in the comparable period of last year, and production in the timber industry was 10 per cent higher. The output of Sweden's iron and steel works in the first half of this year was about 7 per cent higher than in the corresponding period of 1953, but output of the iron ore mines fell by 16 per cent. Employment in the engineering industries of Sweden was about 1 per cent higher at the end of June than it was on the corresponding date of last year.

Notes and Memoranda

Rail and Road

RAIL AND ROAD FARES IN LONDON.—The London Transport Executive has now published details of the increases in road and rail passenger fares which are to take effect on September 26th. The increases will apply to the road and rail services operated by London Transport and to the London area lines of British Railways. It is estimated that the new charges will result in an increased revenue for the London area in a full year of £4,400,000, of which £3,700,000 goes to London Transport and £700,000 to British Railways. This additional revenue is needed mainly to cover wage increases granted at the beginning of the year. London Transport has said that, with these increases, passenger fares will be, on average, 92 per cent above pre-war, but that costs have risen by 140 per cent.

AUTOMOBILE ASSOCIATION'S PROGRESS.—The Automobile Association has stated that it now has 1,500,000 members. The 1,400,000 mark was reached on May 7th this year, and the total has therefore grown by a further 100,000 in 116 days. The A.A. began with fewer than 100 members—and less than £100 in the bank—in 1905. In its early days progress was comparatively slow, and the first 10,000 was not reached until 1909. By 1913 the membership was 50,000 and by 1920 it had reached 100,000. The restriction on private motoring during the war brought the Association's membership down to less than 316,000 in February, 1945, but by June, 1946, the total reached 500,000 for the second time, and the pre-war peak of 731,000 was exceeded in August, 1947, to be followed by the achievement of the 1,000,000 membership on August 15, 1950.

BRITISH MOTOR CORPORATION EXPANSION IN AUSTRALIA.—The British Motor Corporation has announced that within twelve months it will be producing 1000 engines a week in new factory extensions which have just been completed at Victoria Park, Sydney, Australia. It has also acquired a 20-acre site with 250,000 square feet of buildings at Fishermen's Bend, Melbourne, to the value of about A£750,000. This plant, which is conveniently situated across the road from the deep water dock, is to be used for the assembly of British Motor Corporation products made up of parts imported from England and of components and materials made in Australia. In addition to the existing assembly buildings and crane bays, further extensions will be put in hand as quickly as possible to house the press shop for the production of body pressings. Already a detachment of production engineers, technicians and advisory staff has left Birmingham, and the first consignment of machinery is to leave this week. The Melbourne factory now produces Austin bodies, while at Victoria Park, Sydney, Morris vehicles are assembled and bodies painted and trimmed. A very large expansion programme is already under way there to cater for the simultaneous assembly of both Austin and Morris vehicles. The whole project, including purchase of the new site, extensions in both places and the installation of machinery will involve a capital expenditure of about £2,000,000. The British Motor Corporation (Australia) Pty., Ltd., is a wholly owned subsidiary of the British Motor Corporation in England.

Air and Water

BUNKERING SERVICE AT ADEN.—A new dumb barge, "B.P. Aden," has arrived recently at the Aden bunkering installation of the Anglo-Iranian Oil Company, Ltd. The barge, which has a length of 116ft 6in, a beam of 28ft 6in, a maximum draught of 10ft, and a capacity of 500 tons, was built by Clelands (Successors), Ltd., and will supplement the bunkering service, which is mainly carried out by submarine pipelines led from the shore to deep-water mooring berths.

SWEDEN'S MERCHANT FLEET.—It is stated that the Swedish merchant fleet was increased by eight ships, aggregating 36,174 gross tons, during July, and at the end of the month there were in commission 1850 ships, aggregating 2,717,329 gross tons. Recent additions include one turbo-charged combined tanker and ore carrier and two motorships built in Swedish yards, and two steamers and seven motorships purchased from abroad. Motorships now account for 2,089,000 gross tons of the Swedish merchant fleet, and steamers for 567,000 tons.

Miscellanea

ALUMINIUM ALLOY EXTRUSIONS.—We have received from High Duty Alloys, Ltd., a booklet which contains illustrations of some of the range of the extrusions in "Hiduminium" produced by the company.

SAFETY BOARD AT REFINERY.—To promote safety consciousness the Vacuum Oil Company, Ltd., has installed a safety board, at its Coryton refinery, which, by a system of lights, indicates in which department an accident occurred and also records the number of days since the last accident.

CORYTON OIL REFINERY.—The Lummus Company, Ltd., has published an illustrated booklet which describes the construction programme for the oil refinery which the company built at Coryton for the Vacuum Oil Company, Ltd. There are photographs of the main process units, together with the principal construction particulars supplemented with flow diagrams.

SPRING BALANCES CALIBRATED IN NEWTONS.—Spring balances calibrated in newtons are now being made by Geo. Salter and Co., Ltd., of West Bromwich, for use by students of electricity in universities and technical colleges (as recommended by the Institution of Electrical Engineers). It may be recalled that the newton is the M.K.S. (metre-kilogramme-second) unit of force and is defined in B.S. 205 : 1943 as that force which, acting on a mass of one kilogramme gives to it an acceleration of 1m pes second per second. The calibration of the new balances is based on 1 newton being the equivalent of 0·2247 lb. Two sizes of balances calibrated accordingly are available at present : they cover the ranges of 0–20 newtons and 0–50 newtons, respectively, the 6in dial being divided into 200 divisions in each case.

"'GECALLOY' LOW-LOSS CORES AND MICROPOWDER MAGNETS."—Permanent magnets produced from extremely fine powders are described in an illustrated brochure published by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. This brochure gives the properties of these materials and compares them with other magnetic materials.

STIFFENED PANEL CONSTRUCTION BROCHURE.—A brochure with the title "Stiffened Panel Construction in Aluminium," has been published by T.I. Aluminium, Ltd., and describes a new method of constructional technique applicable to many industries. Typical sections of extruded planks are given, and the brochure refers specifically to their use for road-rail containers and barge construction.

ENGRAVING CUTTERS.—A cutter for use on engraving machines, which is now being made by Euco Tools, Ltd., 44, London Road, Kingston, Surrey, has a tungsten carbide core. The makers state that the tungsten carbide core, in addition to giving the tool a long working life between re-grinds when used on normal materials, enables it to stand up well when engraving difficult plastic materials. The cutters can also be used for engraving hardened steel and glass.

PREPACKAGING DRY ROOM.—A dry room to conform to new Ministry of Supply regulations governing the prepackaging of radar and electronic equipment for the services has been built by Geo. Salter and Co., Ltd., at its Spring Road, Smethwick, works. A small section of this organisation, which initially devoted itself to prepackaging the firm's own products to Ministry of Supply standards, has steadily grown and now specialises in tropical packing of goods for other concerns.

INSTRUCTION MANUAL FOR DIESEL ENGINE.—Davey, Paxman and Co., Ltd., has published an instruction manual for the operation and maintenance of Paxman "V.6 RPH," Series I diesel engine package set. The manual gives a general description of the engine and the design principles involved followed by technical data and details of operational procedure. Basic engine components are discussed as are the fuel, lubricating, cooling, induction and exhaust systems, and separate sections are devoted to items such as engine control, and starting pressure charging and the gearbox, flywheel, fluid and gear couplings are reviewed, together with the transmission drive, and the manual concludes with notes upon engine preservation and installation. The manual is fully illustrated with line drawings and coloured diagrams.

ADVANCED LECTURES ON ENGINEERING.—The Manchester and District Advisory Council for Further Education has published a booklet which gives details of the post advanced lecture courses in electrical and mechanical engineering available in the Manchester area in the session 1954–55. All the courses are supported by the North-Western Centre of the Institution of Electrical Engineers and the North-Western Branch of the Institution of Mechanical Engineers. Intending students should have reached a standard at least equivalent to that of the Higher National Certificate and should have sufficient experience to enable them to benefit from the courses. The booklet is available from the Manchester and District Advisory Council for Further Education, Education Offices, Deansgate, Manchester, 3.

APERTURE AND WINDOW ENVELOPES.—We are informed by the Post Office that it is concerned at the large number of items posted in aperture and window envelopes which do not comply with the regulations and are causing embarrassment to sorters and delay to the mails. A considerable proportion of such envelopes sent through the post are carelessly used. The chief faults are : contents badly folded and address partly obscured ; address badly placed by typing out of alignment with cutout or writing too large ; contents smaller than envelope and therefore slipping to bottom, obscuring address ; and cramming the envelope resulting in tearing when passing through stamping machines. Window envelopes cause particular embarrassment when panels are not sufficiently transparent, typing or writing is faint, or enclosures are of coloured paper on which addresses do not show up distinctly. The Post Office appeals to all senders of aperture and window envelopes to help themselves, their correspondents and postal operation by using every care in the correct preparation of these items.

COURSE ON WORKS BUILDINGS AND SERVICES AT NOTTINGHAM UNIVERSITY.—A refresher course on works buildings and services for senior works and plant engineers in the Nottingham area is to be held at the University of Nottingham. It will be presented weekly on Tuesday evenings for a period of twenty weeks commencing on October 19th. Each lecture will be given by specialists drawn from industry, and will be followed by a period for discussion. Advance copies of most lectures will be supplied. The syllabus is designed to promote the application of modern techniques in works engineering practice over a wide field, and includes the following subjects :—Lighting ; heating, ventilating and air conditioning ; electricity, gas and compressed air services ; financial implications of plant installation ; costing of services ; materials handling ; factory planning, layout and architecture ; safety precautions ; industrial effluents problems, and planned maintenance. The honorary secretary, from whom all information can be obtained, is Dr. H. K. Lloyd, departments of civil and mechanical engineering, University of Nottingham, University Park, Nottingham.

REDUCING COKE BREAKAGE IN LOADING.—Breakage of coke as it is loaded from the screens of a carbonisation plant creates a problem in marketing, and in an attempt to reduce this breakage, Mr. P. Bradley, of the carbonisation branch of the National Coal Board's East Midlands Division, has designed an electronically controlled boom for loading the coke into wagons. In the new equipment a device which will register the proximity of a material is attached to the end of the loading boom. The device used is the "Tektor" and it is marketed by Henry Simon, Ltd. When loading, the screen attendant depresses the conveyor boom into a wagon and starts the flow of coke. When the coke level comes to within a few inches of the boom the contacts in the "Tektor" operate to close a relay. Through this relay the electric motor controlling the boom is switched on for one second and causes the boom to rise 9in. This procedure is repeated until the wagon is full, and the periodic elevation of the boom ensures that the distance the coke has to fall is kept to a minimum, thus reducing breakage. With the device in operation a wagon can be safely left without supervision until it is full.

Contracts

R. A. LISTER AND CO., Ltd., Dursley, Gloucestershire, has signed a contract with the signal division of the United States Army in Europe for diesel engine electrical generating sets and spare parts to the value of approximately £285,000. This is the second contract of this kind undertaken by the company for American Forces in Europe.

THE GENERAL ELECTRIC COMPANY, Ltd., has received from Richard Thomas and Baldwins, Ltd., a contract valued at £238,000 for electrical plant and equipment for the Ebbw Vale Steel Works, where an existing three-stand tandem cold mill is to be converted into a four-stand mill. The order covers two 3000 h.p. and one 750 h.p. twin-armature d.c. motors, a six-machine motor generator set driven by a 9000 h.p. 11kV synchronous motor, and all the associated a.c. and d.c. switchgear, together with control gear embodying G.E.C. control exciters.

Personal and Business

MR. S. J. MATTOCK has been appointed publicity manager of Decca Radar, Ltd.

BRITISH ERMETO CORPORATION, Ltd., Maidenhead, states that Mr. Charles Watson, chief sales engineer, has been appointed a director.

CAMBRIAN WAGON AND ENGINEERING COMPANY, Ltd., Maindy, Cardiff, states that Mr. E. H. Jerrett, general manager, has been appointed a director.

GROUP CAPTAIN R. C. RICHMOND has been appointed to the London Office of Marconi's Wireless Telegraph Company, Ltd., for duties concerned with the company's aeronautical radio business.

MR. T. LYNCH, 104, Carter Drive, Havering Park, Romford, Essex, has been appointed representative in the home and eastern counties of Cuxson, Gerrard and Co., Ltd., Oldbury, Birmingham.

FINNEY PRESSES, Ltd., announces that it has been appointed selling agent in this country for the forming, bending and straightening oil hydraulic presses manufactured by Hollmann-Werke G.m.b.H., Wetzlar, Germany.

BROOKS AND WALKER, Ltd., states that Mr. S. R. Webb has been appointed manager of its Liverpool branch in succession to Mr. John Carlisle. Mr. E. C. Coleman has resumed his sales appointment in the Liverpool area.

ARPIC ENGINEERING, Ltd., Queenslie Estate, Glasgow, E.3, announces the appointment of A. Gunn and Co., Ltd., Bold Street Works, Altrincham, Cheshire, as sole agent for its products in Lancashire, Cheshire, the west Riding of Yorkshire, and Derbyshire.

THE MINISTER OF TRANSPORT AND CIVIL AVIATION has appointed Mr. A. B. B. Valentine to be a full-time member of the British Transport Commission. Lieut.-Col. Donald Cameron of Lochiel has been appointed a part-time member of the Commission.

PERMALI, Ltd., announces that, subject to the necessary consents being obtained, a merger with Hordern-Richmond, Ltd., Haddenham, Bucks, has been arranged. Mr. Lawrence Robson, chairman of Hordern-Richmond, Ltd., is to join the board of Permali, Ltd.

MR. G. H. PASSEY has been appointed diesel traction engineer to British United Traction, Ltd., and manager of the company's drawing-office at Boreham Wood. Mr. F. Hodgkinson has also been appointed to the company's engineering staff at Boreham Wood.

MR. J. E. BAGGULEY has been appointed works manager of the Yorkshire Engine Company, Ltd., Sheffield (a branch of the United Steel Companies, Ltd). He succeeds Mr. Rupert Lancaster who has become general works manager of the Distington Engineering Company, Ltd.

POWER-SAMAS ACCOUNTING MACHINES, Ltd., announces the appointment of Mr. Robert Wonfor as managing director (sales, finance and research) and Mr. T. R. Swift as managing director (production). Mr. Wonfor has also been appointed chairman of Power-Samas Developments, Ltd., a subsidiary company. Mr. F. G. S. English has become managing director of that company, and Mr. F. J. Nash has been appointed an additional director.

British Patent Specifications

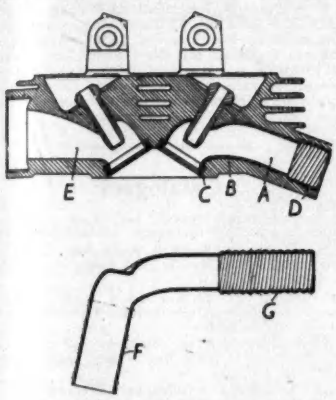
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 6d. each.

INTERNAL COMBUSTION ENGINES

713,109. December 11, 1951.—Inlet and Exhaust Passages of Internal Combustion Engines, N S U Werke Aktiengesellschaft, of Neckarsulm/Württ, Germany.

The invention relates to an internal combustion engine having a cast cylinder head in which one or more inlet and/or exhaust passages are provided with a lining of sheet metal. As can be seen from the drawing, the inlet channel *A* supplying the fuel air mixture is provided with a lining consisting of a sheet iron tube *B*. This extends with its front end



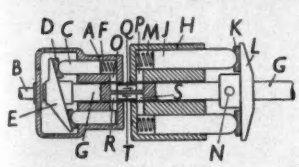
No. 713,109

up to the annular valve seat *C* whilst the rear end is provided with a threaded section *D*. By the insertion of the tube *B* all the irregularities arising in the walls of a channel formed in a casting are definitely avoided. The tube *B* provides an additional support for the annular valve seat *C* and in this way it also ensures a long working life of the engine. The reason that the channel *E* is not provided with any lining is that, according to the tests which have been carried out, it is not of paramount importance that the exhaust pipe shall also be provided with a lining; moreover, as shown, the channel *E* has a less complicated shape than the channel *A* and therefore can be cast with the required degree of precision; however, in certain cases the exhaust channel may also be provided with a lining. The sheet iron tube is preferably assembled from several parts by soldering, welding or riveting. The insertion of the tube can be effected by making it longer than the lining of the finished cylinder head part. The excess parts *F* and *G* are used for anchoring it firmly in a chill mould in which the cylinder head is then cast, so that after the completion of the casting the lining tube is firmly fixed in the cylinder head in the desired position. It is then only necessary to remove the excess material.—*August* 4, 1954.

POWER TRANSMISSION

712,471. December 8, 1950.—Hydraulic Variable Speed Gears, Giovanni Badalini, Via Legnone 19, Milan, Italy.

The invention, as applied to a hydraulic variable speed gear has pump unit plungers with a constant stroke, provision being made for varying the stroke of the plungers of the motor unit for determining the transmission ratio between the driving shaft and the driven shaft. In the drawing, the pump unit is



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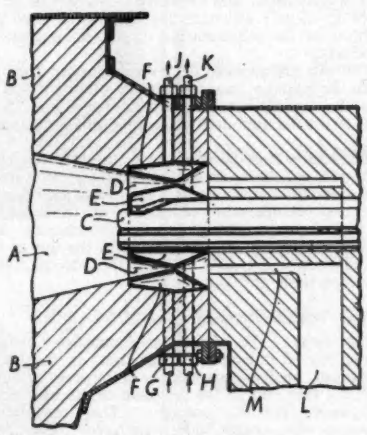
shown to the left and the hydraulic motor unit to the right. The pump unit has a body *A* with which is rigidly associated the input shaft *B*. The body is provided with a number of cylinders within each of which is a plunger *C*. The rounded projecting ends of the plungers are maintained in abutment with pressure pads *D* on a swash plate *E* by means of springs *F*. The swash plate is fixed in a shaft *G* which is coaxial with the input shaft *B*, the shaft *G* constituting the output shaft of the gear. The hydraulic motor unit has a body *H* which is maintained stationary, and has a number of cylinders within each of which is a plunger *J* held in contact with pressure pads *K* on a swash plate *L* by springs *M*. The swash plate is secured on the output shaft by means of a pivot pin *N* and means are provided for varying the angle of inclination of the swash plate *L* relatively to the output shaft *G*. The cylinders of the pump unit are connected with the cylinders of the hydraulic motor unit by ports *O* and *P*, which are connected by a common passage *Q* formed in the output shaft *G* and by ports *R* and *S* which are connected by a common passage *T*, also in the output shaft *G*. The ports *O* and *P* and the passage *Q* serve normally to convey the output of the pump unit to the hydraulic motor unit, whilst the ports *R* and *S* and the passage *T* serve to convey the output of the hydraulic motor unit back to the pump unit. In the specification the operation of the change speed gear is analysed in relation to the various positions of the swash plate.—*July* 28, 1954.

FURNACES

713,004. July 10, 1951.—Production of Combustible Gases by the Gasification of Finely Divided Fuels, Heinrich Koppers, G.m.b.H., 29, Moltkestrasse, Essen, Germany.

The invention relates to the production of combustible gases by the gasification of finely divided fuels, particularly finely divided solid fuels, with oxygen and, possibly, steam, the fuel being suspended in the gaseous medium during the reaction and moving in substantially the same direction. In the apparatus shown in the drawing the gasification takes place in the reaction chamber *A*, widening conically in the direction of flow, and having walls *B* of refractory material. The end wall of the reaction



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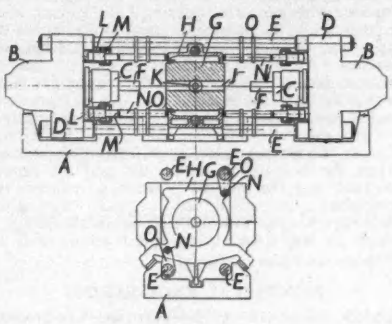
chamber in which lie the inlets for the gasification media is formed of water-cooled metal surfaces. The fuel dust-oxygen mixture is injected centrally through three water-cooled nozzle pipes *C*. These pipes are surrounded by the annular steam nozzle *D*, the hollow walls of which, as indicated at *E* and *F*, form cooling jackets. To the two jackets there is supplied cooling water under pressure through the pipes *G* and *H*, whilst the heated water flows away through pipes *J* and *K* respectively. The annular nozzle *D* has a similar profile to a Laval nozzle. Superheated steam is supplied to it from the rear through the passage *L* and the annular distributing passage *M*. The nozzle surrounding the central nozzle pipes for the fuel-oxygen mixture which serves to form the envelope of gaseous medium, is bounded both at it inner as well as its outer surface by separate cooling jackets which serve only to cool the annular nozzle and are independent of each other as regards the cooling medium. A modified construction of nozzle head is also shown in the specification.—*August* 4, 1954.

MACHINE TOOLS

712,529. July 12, 1951.—Double-Acting Billet Extrusion Presses, The Loewy Engineering Company, Ltd., Manfield House, 376, Strand, London, W.C.2. (*Inventor: Eric Norman.*)

An object of the invention is to provide a double-acting billet extrusion press having improved means for supporting its container against axial displacement. The press shown in the drawing has a bed *A* which, at each end, supports a hydraulic cylinder *B*, having a ram *C*. The two cylinders have lugs *D* through which columns *E* are passed and are fastened to the lugs. Attached to the rams are pressing stems *F*. A container unit, comprising a container proper, *G*, and a holder *H* is arranged midway between the cylinders, the container having a billet chamber *J* which extends from one end of the container to the other and is of uniform diameter throughout. The extrusion tools—of which one only is shown at *K*—are arranged radially with respect to the axis of the billet chamber. The pressing stems *F* are so arranged that they can enter the billet chamber from each end and act in opposition, extruding the billet metal



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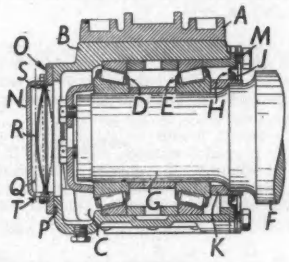
through one of the tools *K*. Such presses are particularly suitable for the extrusion of a continuous sheathing of aluminium or light metal around an electric cable. The container holder *H* has feet which rest on guideways on the base frame *A* and is thus slidingly supported in the press. Arranged in the spaces between the container unit and the end cylinders are thrust bearings capable of balancing axial forces to which the container unit is subjected. They consist each of a cylinder *L* and a ram *M*, the former being mounted on the cylinders *B* and the latter being displaceable in cylinders *L* in a direction parallel to the axis of the press. Interposed between the rams and the container holder are distance pieces or spacer members *N* supported in brackets *O* attached to the press columns *E*. As can be seen in the lower view, two thrust bearings on both ends of the container unit are arranged diametrically opposite each other to avoid the effect of eccentric forces on the container unit. In practice, the spacer members *N* are so positioned relative to the container holder *H* that a small clearance is left between them and the container holder. By equalising the pressures which act on the pressing stems *F* during extrusion, the axial forces acting on the container unit are balanced, and the container unit will therefore not tend to be displaced on its guideways.—*July* 28, 1954.

BEARINGS AND SUPPORTS

712,493. August 28, 1951.—Bearing Mountings with a Pressure Responsive Closure, The Timken Roller Bearing Company, 1835, Dueber Avenue, S.W., Canton, Ohio, U.S.A. (Assignees of Ernest G. Boden).

The invention relates to sealed shaft or axle bearing mountings, and is particularly concerned with improvements in the sealing provisions for railway axle bearing mountings. The drawing shows the invention applied to a railway wagon with the side frame



No. 712,493

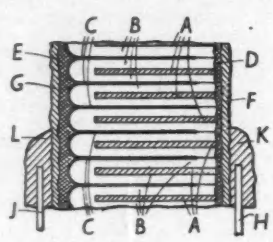
A supporting a bearing housing *B*, which is open at both ends, and has an oil chamber *C* for the lubrication of the two tapered roller bearings *D* and *E*. The inner end of the bearing housing *B* is sealed by a flexible ring *H* which has an enlarged inner flange *J* closely fitting a backing sleeve *K* to seal off the adjacent axle zone *G*. The outer flange of the sealing ring is clamped to the side of the housing by a backing ring *M*. In many applications of such bearings, closed by a rigid or non-flexible member, the temperature within the bearing rises in service, and an excess pressure is built up which is often sufficient to force lubricant through the sealing means or blow them out. When at rest and cooling off, the temperature falls, and forms a partial vacuum in the chamber which may suck in contaminated grease, dirt and water and so contaminate the lubricating oil. The invention overcomes these disadvantages by a breather-type of sealing diaphragm. This consists of an outer cap *N*

mounted on the end face of the housing by the flange *O* and studs. It provides a space *Q* adjacent to the oil chamber *C*. This space is separated from the bearing housing chamber by a flexible diaphragm *R*, which also forms an oil seal. The diaphragm may be made of suitable metal and it is shrouded by a mounting ring *S* of rubber or other suitable resilient material, and is carried in a recess in the cap *N*. The cap is further provided with a breather opening *T*. In service, when the pressure in the chamber is equal to that within the cap space, the diaphragm is in its normal unflexed position. As the bearing heats up and the internal pressure in the chamber rises, the diaphragm flexes outwardly until the internal and external pressures are in equilibrium. The diaphragm is designed to flex at a lower pressure than that needed to move or displace the sealing ring *H* from its normal position. When the bearing cools, the air and oil vapour contract, and the internal pressure is reduced, the atmospheric pressure in the cap space causing the diaphragm to flex inwards. Some modifications in design are also shown in the specification.—*July* 28, 1954.

ELECTRICAL ENGINEERING

712,559. June 16, 1952.—ELECTRIC CONDENSERS, Siemens and Halske Aktiengesellschaft, Siemensstadt, Berlin, and Wittelsbacher Platz 4, Munich 2, Germany.

The invention relates to electric condensers consisting of a number of alternate layers of electrode material and dielectric, the latter being of synthetic material and alternate electrode layers being carrier layers for the dielectric material. As shown in the drawing, the carrier electrodes of the condenser *A* are formed of aluminium foil. Each electrode has a layer of varnish *B* on both sides. The counter-electrodes are formed by a layer *C* of aluminium,

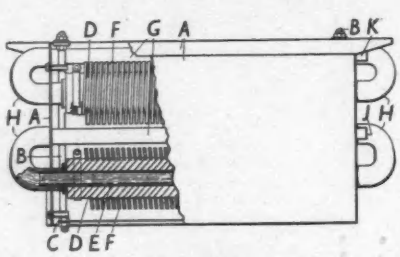


No. 712,559

which is applied to the varnish layer *B* by vaporisation. The counter-electrodes extend over the edges of the varnish layers *B*, embracing the end faces, as shown in the drawing. Contact at the ends of the two carrier electrodes *A* and the counter-electrodes *C* is effected, in accordance with the invention, by thin continuous layers *D* and *E* respectively consisting of copper or a copper alloy, the layers being applied by vaporisation or spraying and adhering securely to the carrier electrodes and counter-electrodes. A further layer *F* and *G*, consisting of a readily solderable metal, such as tin or the like, is applied to each end layer *D* and *E* in the same way. Contact lugs *H* and *J* are soldered to the outer layers *F* and *G* for leading in the current, the end layers preferably being thickened by means of additional layers of tin *K* and *L*.—*July* 28, 1954.

712,693. March 13, 1951.—STARTING RESISTANCES FOR ELECTRICALLY PROPELLED VEHICLES, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. (*Inventor : Edward Hugh Croft.*)

The invention relates to starting resistances for electrically propelled vehicles, such as electric trolleybuses and electric rail vehicles. Referring to the drawing, the starting resistance comprises sheet steel covers *A* made up into a boxlike frame by rods *B* and



No. 712,693

the frame is ventilated at least in part by apertures *C* at some edges. The frame supports a number, say six, of insulating tubes *D*, which are arranged parallel to one another and run from end to end of the resistance. The tubes are arranged in two rows of three, one above the other, and each tube is carried by an inner metal tube *E* through which water is circulated. Wound on each insulating tube *D* is resistance wire *F*, which may be of strip form wound on edge and the wire on the six tubes may be connected in series or in other suitable manner dependent on the duty required of the resistance. Return metal tubes *G* are provided between the metal tubes *E* in the insulating tubes *D* and the whole series of metal tubes *E* and *G* are connected by suitable end connections *H* into a continuous circuit, having an inlet *J* and an outlet *K* at one end of the resistance. The two rows of return tubes *G* lie one row above the associated row of insulating tubes *D* so that heat generated by the resistance wire rising passes over the exterior of the return tubes *G* and the tubes can, if desired, be suitably ribbed or provided with fins to increase their surface area and the amount of heat which they can absorb. The starting resistance described forms a combined resistance unit and water heater, water being arranged to be circulated through the metal tubes, and the water which is heated in the resistance would be supplied to some form of radiator say, in the saloon of the trolleybus. Since the water circulating system has a considerable heat capacity, the peaks of heat in the starting resistance itself are smoothed out and the heat generated is efficiently used in the trolleybus.—*July* 28, 1954.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

DATA SHEETS FOR LIMITS AND FITS

No. 1916C and No. 1916D. Price 1s. each.—Following on the publication of B.S. 1916, Parts 1 and 2, these data sheets give primary and secondary selections of fits extracted from the main standard.

It is considered that the simple selection of six fits given in sheet 1 will meet the needs of a large proportion of the requirements of normal engineering products.

The five fits given in data sheet number 2 supplement the primary selection, and it is thought that the two sheets will, between them, cover about 95 per cent of the fits used in average good-quality engineering.

The sheets have been issued in the form which, it is hoped, will be most serviceable to drawing-offices and standards departments. Designers are urged to give first consideration to these restricted selections of fits wherever possible, since concentration on a limited number of fits, coupled with the use of preferred sizes, will greatly facilitate the introduction of standard tools and gauges.

WATERPROOF DRAWING INKS

No. 2490 : 1954. Price 3s.—Extensive investigations, carried out among large users in the United Kingdom, on the demands for waterproof coloured drawing inks, led to the selection of eleven colours, designated B.S(DI) colours. They are violet, Prussian blue, cobalt blue, light green, dark green, yellow, orange, vermilion, scarlet, carmine and brown. The scope of the specification is limited to water soluble dyes. These colours are defined, with suitable tolerances, in terms of the X, Y and Z stimuli of the International Commission on Illumination (C.I.E.) determined from absorbent filter paper test strips prepared according to a closely defined procedure. It is emphasised in the standard that the colours as shown on the chart appear necessarily darker than they would if they were applied as washes on cartridge paper. The standard also specifies suitable tests for the definition of the qualities considered necessary in a good drawing ink. These are : draughting, keeping and erasing qualities, and resistance to light and solvents. Waterproof black carbon inks are also included in the standard, but only from the point of view of the tests of quality enumerated above. No attempt has been made to define colour tone, denseness, opacity, resistance to crazing and flaking—qualities for which, it was considered, no satisfactory tests could at present be devised. Standard sizes of containers and methods of sealing are recommended, and the meaning of the B.S.I. certification mark is explained.

Launches and Trial Trips

GRANBY QUEEN, trawler ; built by John Lewis and Sons, Ltd., for Talisman Trawlers, Ltd.; length overall 113ft 6in, length between perpendiculars 100ft, breadth moulded 22ft, depth moulded 10ft 9in ; Crossley H.R.N.6 diesel engine, 440 b.h.p. at 300 r.p.m. Launch, August 12th.

VASSILIKI, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for the Nueva Vista Compania, Naviera S.A., Panama ; length between perpendiculars 496ft, breadth moulded 67ft 6in, depth moulded 36ft 5in, draught 29ft 1¼in, deadweight 16,250 tons, trial speed 14 knots ; twenty-seven oil cargo tanks, one main pump room, three 500 tons per hour cargo oil pumps, one 150 tons per hour stripping pumps, steam deck machinery ; two 60kW steam-driven generators ; Hawthorn-Doxford single-acting, two-stroke oil engine, five cylinders 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m., two Scotch boilers. Launch, August 18th.

BRITISH SERGEANT, oil tanker ; built by Harland and Wolff, Ltd., at Govan for the British Tanker Company, Ltd.; length overall 518ft, length between perpendiculars 490ft, breadth moulded 65ft, depth moulded 36ft, deadweight 14,000 tons ; twenty-seven cargo oil tanks, two main cargo pump rooms, steam deck machinery, two 125kW diesel-driven generators, one 50kW steam-driven generator; Harland - B. and W. two-stroke, single-acting, opposed-piston diesel engine, six cylinders 620mm diameter by 1870mm combined stroke, 115 r.p.m., two single-ended multitubular boilers. Trial, August 19th.

OLYMPIC SPLENDOUR, oil tanker ; built by the Ateliers et Chantiers de la Ciotat for Mr. Onassis ; length overall 660ft, length between perpendiculars 631ft, breadth moulded 86ft 9in, depth moulded to main deck 45ft, draught loaded 33ft 11in, deadweight 31,500 tons, thirty oil cargo tanks ; one set of double-reduction geared C.E.M.-Parsons turbines, 15,000 s.h.p., steam supplied at 640 lb per square inch and 850 deg. Fah. by two Foster-Wheeler boilers, trial speed 16·7 knots with 13,750 s.h.p. at 105 r.p.m. of propeller. Trial, August.

R. B. WATERSTON, tug ; built by William Simons and Co., Ltd., for the South African Railways and Harbours Administration ; length overall 155ft, breadth moulded 34ft, depth moulded 17ft 6in, steam deck machinery, speed 13 knots ; two sets of triple-expansion, surface condensing engines, steam supplied at 200 lb per square inch by four cylindrical multitubular boilers. Launch, August 21st.

Catalogues

WILKINSON RUBBER LINATEX, Ltd., Camberley, Surrey.—Brochure giving details of the range of Linatex centrifugal pumps.

HILGER AND WATTS, Ltd., 98, St. Pancras Way, Camden Road, London, N.W.1.—Brochure CH 356/2, Hilger micro-focus X-ray unit.

J. H. SANKEY AND SON, Ltd., Ilford, Essex.—Leaflet giving particulars of "Aluma" fire cements and "Siluma" hot patching cement.

THERMIX INDUSTRIES, Ltd., 29, Grosvenor Place, London, S.W.1.—Brochure describing the "Tubix" multi-cyclone dust collector.

SUFFOLK IRON FOUNDRY (1920), Ltd., Sifbronze Works, Stowmarket, Suffolk.—Technical leaflets describing welding of stainless steel by Sifsteel and Sifbronze methods and welding zinc-base die castings by process 31.

A. A. JONES AND SHIPMAN, Ltd., Narborough Road South, Leicester.—List 214, describing the precision semi-universal grinder. List 125G, describing the Model 1235 cutter and tool grinding machine, and List 215, illustrating and describing precision grinding machines.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB

Fri. to Mon., Sept. 24th to 27th.—Church House, Westminster, London, S.W.1, 29th Annual Conference.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 29th.—London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Computing Circuits in Flight Simulators," A. E. Cutler, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Sept. 7th.—LONDON BRANCH : Royal Society of Arts, John Adam Street, London, W.C.2, Open Forum, 7 p.m.

Thurs., Sept. 9th.—NORTH EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "The Engineering Application of Electro-Deposited Metals," J. W. Oswald, 7 p.m.

Wed., Sept. 15th.—KENT BRANCH : Bull Hotel, Rochester, Kent, "The Causes and Prevention of Steam Plant Scale," W. F. Gerrard, 7 p.m.—WESTERN BRANCH : Grand Hotel, Bristol, "Planning and Reconstruction of Bristol," R. W. Jefford, 7.15 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 8th.—26, Portland Place, London, W.1, "The Application of Turbogrid Trays in the Petroleum Industry," G. J. van Den Berg, 5.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., Sept. 14th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Current American Practice in Heating, Ventilating and Air Conditioning," John K. M. Pryke, 6 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Thurs., Sept. 9th.—WOLVERHAMPTON SECTION : Technical College, Wulfruna Street, Wolverhampton, 1954 Sir Alfred Herbert Paper, "Some Problems of Higher Technological Education," The Rt. Hon. The Earl of Halsbury.

IRON AND STEEL INSTITUTE

Mon. to Thurs., Sept. 13th to 16th.—IRON AND STEEL ENGINEERS GROUP : 26th Meeting, Newcastle upon Tyne : the meeting will be devoted to the presentation and discussion of seven papers on the developments at Consett Works, followed by visits to the works at Consett and Jarrow, and the Ore Discharge Terminal at Tyne Improvement Commissioners Quay.

JUNIOR INSTITUTION OF ENGINEERS

Mon., Sept. 6th.—14, Rochester Row, Westminster, S.W.1, meeting of the Finance and General Purposes Committee, 6 p.m.